



Examining the Mortality of an Unsheltered Homeless Cohort From Boston, MA, 2000 Through 2009

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**EXAMINING THE MORTALITY OF AN UNSHELTERED HOMELESS COHORT
FROM BOSTON, MA, 2000 THROUGH 2009**

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A Dissertation Submitted to the Faculty of
The Harvard T.H. Chan School of Public Health
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EXAMINING THE MORTALITY OF AN UNSHELTERED HOMELESS COHORT

FROM BOSTON, MA, 2000 THROUGH 2009

ABSTRACT

Purpose: This dissertation addressed a gap in homelessness literature by examining mortality outcomes of an unsheltered cohort and by applying criteria developed at the Boston Health Care for the Homeless Program (BHCHP) to predict mortality.

Methods: A 10-year prospective study was conducted with 445 unique unsheltered individuals. Data were collected during encounters with BHCHP's Street Team clinicians, an integrated program providing care to homeless adults living outside. Decedent data were matched to the Massachusetts Department of Public Health death occurrence files. Analyses included describing the cohort and the high-risk criteria, calculating age-standardized all-cause and cause-specific mortality rates and age-stratified rate ratios using two comparison groups: the Massachusetts population and a general homeless cohort, and conducting survival analysis. The same methods were used when the high-risk for mortality was applied and the cohort was divided into a high-risk group and non-high-risk group.

Results: During the study, 134 deaths occurred. The average age of death was 53 years old. The cohort was largely white and men. Blacks had a lower rate of death compared to whites. The all-cause mortality rate that was almost 10 times higher than the Massachusetts population and nearly three times higher than the general homeless cohort. The most common causes of death were noncommunicable diseases and causes attributable to substance use. Survival analysis showed low probabilities of survival and high rates of mortality for older age groups, men, and whites. Similar patterns of mortality outcomes were seen when the high-risk for mortality criteria were applied. The high-risk group had higher mortality rates than the non-high-risk group; both groups had higher mortality rates for comparisons to Massachusetts and for most comparisons to the general homeless cohort. Survival analysis showed lower probabilities of survival and higher rate of death for the high-risk group.

Conclusions: Deaths occurred prematurely and the leading causes of death were common causes seen in the general population. The high-risk for mortality criteria predicted an increased mortality rate. The results were seen despite near-universal access to insurance and care. Future studies are warranted to further understand these health disparities and the social determinants for the unsheltered population.

TABLE OF CONTENTS

Abstract	ii
List of Figures with Captions	v
List of Tables with Captions	vi
Acknowledgements	vii
Quotations	ix
Preface	x
Paper One	1
Abstract.....	2
Introduction.....	3
Methods.....	5
Results	12
Discussion	16
Conclusion	23
Tables.....	24
Paper Two	30
Abstract.....	31
Introduction.....	32
Methods.....	33
Results	38
Discussion	39
Conclusion	43
Tables and Figures	45
Paper Three	51
Abstract.....	52
Introduction.....	53
Methods.....	56
Results	62
Discussion	64
Conclusion	70
Tables and Figures	71
Bibliography	80

LIST OF FIGURES

Paper Two: Relative Survival of Rough Sleepers: survival analysis of an unsheltered adult homeless cohort from Boston, MA, 2000 through 2009

Figure 2-1: All-Cause Mortality for Unsheltered Cohort

Figure 2-2: All-Cause Mortality for Unsheltered Cohort by Age

Figure 2-3: All-Cause Mortality for Unsheltered Cohort by Age and Gender

Figure 2-4: All-Cause Mortality for Unsheltered Cohort by Age and Race/Ethnicity

Paper Three: High-Risk for Mortality Criteria and Rough Sleepers: 10-year prospective study of high-risk and non-high-risk unsheltered adults from Boston, MA, 2000 through 2009

Figure 3-1: All-Cause Mortality for Unsheltered Cohort by Risk-Level and Young Age (18-44 years old)

Figure 3-2: All-Cause Mortality for Unsheltered Cohort by Risk-Level and Middle Age (45-64 years old)

Figure 3-3: All-Cause Mortality for Unsheltered Cohort by Risk-Level and Old Age (65-84 years old)

LIST OF TABLES

Paper One: Mortality Among Rough Sleepers: 10-year prospective study of an unsheltered adult homeless cohort from Boston, MA, 2000 through 2009

Table 1-1: Characteristics of the Unsheltered Cohort from 2000-2009

Table 1-2: Additional Characteristics of 134 Unsheltered and Massachusetts Decedents from 2000-2009

Table 1-3: Age Specific, Race/Ethnicity Specific, and Gender Specific Rate Ratios for Unsheltered Cohort, 2000-2009

Table 1-4: Age Specific Rate Ratios for Unsheltered Cohort, 2000-2009 Compared to Massachusetts Population, 2000-2009 and to General Homeless Cohort from Boston, MA, 2003-2008

Table 1-5: All-Cause and Cause-Specific Age-Standardized Mortality Ratios for the Unsheltered Cohort, 2000-2009 Compared to the Massachusetts Population, 2000-2009 and to a General Homeless Cohort from Boston, MA, 2003-2008

Supplemental Table: International Classification of Diseases 10th Revision (ICD-10) Codes Used and Definitions of Causes of Death

Paper Two: Relative Survival of Rough Sleepers: survival analysis of an unsheltered adult homeless cohort from Boston, MA, 2000 through 2009

Table 2-1: Characteristics of the Unsheltered Cohort from 2000-2009

Table 2-2: Cox Proportional Hazard Model for Unsheltered Cohort from 2000-2009

Paper Three: High-Risk for Mortality Criteria and Rough Sleepers: 10-year prospective study of high-risk and non-high-risk unsheltered adults from Boston, MA, 2000 through 2009

Table 3-1: Characteristics of Unsheltered Cohort from 2000-2009

Table 3-2: Cox Proportional Hazard Model for the Unsheltered Cohort from 2000-2009

Table 3-3: Age Specific, Race/Ethnicity Specific, Gender Specific, and Risk-Level Specific Mortality Rate Ratios for Unsheltered Cohort from 2000-2009

Table 3-4: Age Specific Rate Ratios for Unsheltered High-Risk Cohort, 2000-2009 Compared to Massachusetts Population, 2000-2009 and to General Homeless Cohort from Boston, MA, 2003-2008

Table 3-5: All-Cause and Cause-Specific Age-Standardized Mortality Ratios for the Unsheltered Cohort, 2000-2009 by Risk-Level Compared to the Massachusetts Population, 2000-2009 and to a General Homeless Cohort from Boston, MA, 2003-2008

Supplemental Table: International Classification of Diseases 10th Revision (ICD-10) Codes Used and Definitions of Causes of Death

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QUOTATIONS

And therefore to repair his Strength he tries:
Hardening his Limbs with painful Exercise,
And rough upon the flinty Rock he lies.
On prickly Leaves, and sharp Herbs he feeds,
Then to the prelude of a War proceeds.
His Horns, yet fore, he tries against a Tree:
And meditates his absent Enemy.”

Virgil, translated into English verse by Mr. Dryden. *Geor. III. GEORGICS*. The works of Virgil containing his Pastorals, Georgics and Aeneis: adorn'd with a hundred sculptures. 1697. p. 107, verse 355-361.

rough – “to lie rough, in one’s clothes all night”

E. B. *A new dictionary of the terms ancient and modern of the canting crew: in its several tribes of Gypsies, beggars, thieves, cheats, &c.: with an addition of some proverbs, phrases, figurative speeches, &c. useful for all sorts of people, (especially foreigners) to secure their money and preserve their lives, besides very diverting and entertaining being wholly new*. London: Printed for W. Hawes and W. Davis; 1699.

sleep rough – British – “Sleep in uncomfortable conditions, typically outdoors”

Oxford University Press. Definition of sleep rough in Oxford Dictionaries. 2016; Available:

http://oxforddictionaries.com/definition/american_english/rough?region=us&q=sleeping+rough#rough_52. Accessed 8/19/2016.

PREFACE

Homelessness can be viewed as a prism that refracts the weaknesses in many sectors of society: welfare, education, labor, justice, health care, and housing and is a manifestation of extreme poverty. Those experiencing homelessness for brief or prolonged periods are a cross-section of society, including children and families, adolescents, unaccompanied adults, and the elderly. The causes of homelessness are manifold and complex, occurring at the individual and population level in society. Thus the homeless population is not homogenous but rather a mosaic of many sub-groups, each with differing needs. This dissertation focuses upon the sub-group of homeless individuals referred to as unsheltered or rough sleepers, those elusive yet highly visible homeless adults who sleep on park benches, in doorways, down back alleys, in subway and train stations, and other crevices and interstices of urban landscapes across the United States (U.S.). In U.S. literature, this sub-group is commonly referred to as “unsheltered,” while “rough sleepers” is primarily a British term with multiple literary references dating back to John Dryden’s translation of Virgil Georgics III in 1697.¹⁻³ The earliest references to sleeping rough were of soldiers during wartime battles, and ultimately the term evolved to refer to homeless people sleeping outside.^{3, 4}

The definition of homelessness has changed throughout the history of the U.S., reflecting both economic fluctuations and shifting societal attitudes toward poor and socially excluded persons.⁵ During the era of the Great Depression, homeless persons were referred to as transients, tramps, hobos, “gentlemen of the road,” or those who were “down and out.”⁵ It was not until the 1980s that the term “homeless” gained notoriety.⁵ It was also during this time that the face of homelessness changed.⁵ The shift in the general homeless population went from an older white man in his 50s sleeping in flophouses, cheap hotels, and single room occupancies, or SROs, to a younger person in their 40s who was more impoverished, more likely to be from a minority group, and had more disability which were barriers to employment.⁵ During this time, women and families as well as those sleeping outside appeared in greater numbers.⁵ In the urban setting, homelessness was more visible than ever before.⁵ Despite over 30 years of visibility, the unsheltered population is still not well understood.

The shift in demographics for the homeless population during the 1980s has been largely attributable to three factors: gentrification of urban and Skid Row areas, deinstitutionalization of the chronically mentally ill population, and decriminalization of public inebriation in some cities.⁵ Sociologist Dr. Peter Rossi referred to those identified as homeless during and after the 1980s as the “new homeless,” to distinguish them from their predecessors.⁵ The new homeless experienced “literal homelessness,” with large numbers warehoused in emergency shelters or sleeping on the streets.⁵ Since the 1980s, homelessness has been defined by an absolute lack of housing, by living in other places not suitable for human habitation.^{1,2,5} In 1987, Congress formally defined homelessness with the passage of the McKinney-Vento Act, Section 725, which designated homeless persons as a special population with protected funding.⁶

Homelessness is typically divided into three categories: individual or adult homelessness, family homelessness, and youth and adolescent homelessness. Each category can be further divided into subgroups, such as the elderly, veterans, and unsheltered individuals and families. Kuhn et al. 1998 used a typology to also categorize homelessness. Their study of utilization patterns of homeless persons in public shelters in New York City (NYC) and Philadelphia during the 1990s found (1) 80% were transiently homeless using the shelter for a single brief stay; (2) 10% were episodically homeless with many repeated shelter stays; and (3) 10% were chronically homeless, sleeping every night in a shelter.⁷ The group of chronically homeless individuals occupied 50% of the shelter time.⁷ Research conducted since their paper, has shown that a large proportion of the unsheltered population meets the definition for chronically homeless set by The U.S. Department of Housing and Urban Development’s (HUD) in 2003 and redefined in 2015; instead of spending every night in a shelter, they sleep outside every night.^{1, 7-10}

Estimates of the homeless population in American have varied widely from 250,000 (<0.1% of current U.S. population) to as high as 3.5 million (>1% of current U.S. population).¹¹ The wide variation in estimates is emblematic of the methodological challenges faced by researchers in defining and enumerating the homeless population. In response to Congressional directives in 2001, HUD began to assist communities across the U.S. to systematically collect data on people experiencing homelessness

and since 2005 have annually produced a report called the Annual Homeless Assessment Report (AHAR) to Congress.⁹ The primary data for enumerating the unsheltered population in the AHAR have come from point-in-time (PIT) counts, single night counts during the month of January of sheltered and unsheltered homeless people in communities across the U.S.⁹ The most recent AHAR from January, 2015, found 152,806 unsheltered individuals, representing 43% of the 358,422 adult homeless individuals in the U.S.¹ Overall, 564,708 homeless persons were counted in January 2015.¹ The number of unsheltered individuals has decreased 23.5% since 2007; although the 2015 count showed an increase of 1.2% in individuals sleeping outside since 2014.^{1, 12}

HUD is responsible for the definition for the homeless population as well as sub-populations. An unsheltered person is someone who does not use shelters but whose primary nighttime residence is a public or private place not designated or ordinarily used for sleeping, such as sidewalks, abandoned buildings, parks, or cars.^{1, 2} The HUD definition also treats those living in urban and rural settings equally. HUD's definition of unsheltered does not have a time or choice component. An individual counted as unsheltered during a PIT count could have been sleeping outside continuously or for the first time.

The City of Boston conducted its first homeless census in 1983 and an annual homeless census since 1987.¹³ The Boston 2015 PIT count of people sleeping on the streets on a January night was 139.¹⁴ In the summer, the unofficial counts in Boston have been known to be 1000 or more. The official PIT counts in January in Boston are influenced by temperature and weather, as more people tend to stay outside on a warmer night, and which neighborhoods are included from year to year.

Some U.S. cities have tried to decrease the numbers of unsheltered by creating direct access to shelter beds through city's emergency shelter systems. NYC has had a legal right to shelter since the 1970s; the City and State of New York are obligated to provide shelter and board to all homeless people in NYC.¹⁵ Since the early 1980s, Boston has guaranteed a shelter bed for all homeless individuals and families.¹⁶⁻¹⁸ Additionally, Boston's adult shelters are "wet," without requirements for sobriety, and have no limit on the length of time one can stay. Those sleeping outside in Boston and NYC do not utilize the shelters for many reasons, such as fear of large crowds, intolerance of the rules, and fear of withdrawal

once inside the shelters; as such, they might differ from those on sleeping on the streets in cities with insufficient numbers of shelter beds, “dry” shelters with requirements for sobriety, or limitations on the number of nights individuals may use shelters.

Despite the visibility of unsheltered homeless population across the urban landscape, this group is paradoxically the least understood. Homeless research has focused largely on individuals and families who access shelters primarily due to convenience.⁵ Few studies of the street population have been done, those conducted have been largely descriptive or cross-sectional.^{5, 19, 20} No study to date has followed a cohort of rough sleepers prospectively for a decade, reflecting the challenges of engaging an itinerant group. The studies that do exist of the unsheltered population described physical complaints and noncommunicable illnesses such as cancer, heart disease, and diabetes, reported substance use and mental illness.^{19, 21-25} Studies have been inconsistent, showing varying rates of insurance, health care utilization, entitlements, and access to basic needs such as showers and food, likely reflecting the geographic variations of the unsheltered population and the inconsistent availability of health insurance and access to services across the U.S.^{19, 21, 25-27} The few studies devoted to unsheltered individuals report a demographic of older white men who have been homeless longer than their shelter-dwelling counterparts.^{5, 20, 22, 28} Unsheltered individuals can be difficult to engage and labeled resistant to care, especially when mainstream services are available, leading care givers and researchers to conclude that to adequately care for and better understand an unsheltered adult population, aggressive outreach efforts are needed.^{19, 21-23, 25}

This dissertation emerged from the innovative health care service delivery model used by the Boston Health Care for the Homeless Program’s (BHCHP) Street Team, a multidisciplinary team who provide integrated medical and behavioral health care throughout the day and night to the unsheltered population in Boston. The team’s mission is to provide the highest quality health care to rough sleepers by offering continuity of care from the street to the clinic to the emergency department and hospital to respite care and to housing.²⁹ Every opportunity is seized to have coffee or sit on a bench to hold a conversation in an effort to earn trust and rapport through a consistent presence. The core of the service delivery model is an enduring relationship between the team and the patient. A consistent presence on the

streets by the team of doctors and psychiatrists, nurse practitioners and physician assistants, and social workers and case workers for more than thirty years has earned the trust of this sub-group of Boston's homeless population which translated into the database used for this doctoral dissertation. The primary aim of this dissertation was to describe the group of elusive men and women who have lived homeless outside in Boston as well as to depict the disparity of mortality for the unsheltered cohort when compared to both the Massachusetts population from 2000 through 2009 and a general homeless cohort from Boston from 2003 through 2008.

PAPER ONE

Mortality Among Rough Sleepers: 10-year prospective study of an unsheltered adult homeless cohort from Boston, MA, 2000 through 2009

ABSTRACT

Purpose: This study addressed a gap in homelessness literature by describing an unsheltered adult cohort from Boston, MA, and calculating age-standardized all-cause and age-standardized cause-specific mortality rates as well as age-stratified mortality rate ratios using two comparison populations: the Massachusetts population from 2000 through 2009 and a general homeless cohort from Boston, MA from 2003 through 2008.

Methods: The design was a 10-year prospective study. The population included 445 unique unsheltered individuals who met eligibility criteria. Data consisted of information collected during face-to-face encounters with Boston Health Care for the Homeless Program's Street Team clinicians and were matched to the Massachusetts Department of Public Health death occurrence files. Descriptive analyses were compiled and all-cause and cause-specific mortality rates and age-stratified rate ratios were calculated. Goodness of fit tests were conducted to determine if there was a significant difference between number of deaths observed compared to number of deaths expected.

Results: During the study, 134 individuals died. The average age of death was 53 years old. The cohort was largely white and men. Blacks had lower rate of death compared to whites. The unsheltered cohort had an all-cause mortality rate that was almost 10 times higher than the Massachusetts population and nearly three times higher than the general homeless cohort. The most common causes of death for the unsheltered cohort were noncommunicable diseases and causes directly attributable to substance use.

Conclusions: Mortality rates for unsheltered individuals were higher than both the non-homeless population and the general homeless cohort. Deaths often occurred at a premature age and the most common causes of death for the unsheltered cohort were diseases and conditions that would have been preventable and treatable if diagnosed early. Research aimed at understanding the social determinants for the unsheltered population is imperative to inform future policies and interventions that can reduce morbidity and mortality for the unsheltered population by offering something beyond a comprehensive patient-centered medical and behavioral health service delivery model.

INTRODUCTION

A paucity of literature exists for the unsheltered homeless population who visibly live and die on the streets of cities across the United States (U.S.). They comprise almost a third of the general homeless population.¹ The Annual Homeless Assessment Report (AHAR) of the U.S. Department of Housing and Urban Development (HUD) to Congress in January 2015 found 564,708 people who were homeless in the U.S. with 31% living unsheltered.¹ The majority of the people sleeping outside were individuals older than 24 years old, men, and white or non-Hispanic.¹ The 2015 report was the first AHAR since initial publication in 2005 to include demographics such as race/ethnicity and gender for the unsheltered population.¹ In prior AHARs, information on unsheltered people was reported solely by “household” type: individual versus family.^{1, 2, 9, 12} While past studies of unsheltered adults have shown a population with high burden of co-occurring medical and behavioral health problems, no study to date has examined the all-cause and cause-specific mortality rates for this sub-group of the homeless population.^{19, 21, 23, 25} In order to address the unique needs and overcome the myriad obstacles to care for this vulnerable population, an understanding of the demographics, mortality, and causes of death was critical to inform health care and social policies to create effective models of care and services capable of reducing these disparities.

Compared to non-homeless populations, the general homeless population has been shown to die prematurely, have high all-cause and cause-specific mortality rates, and high prevalence of acute and chronic conditions.³⁰⁻³⁵ Homeless mortality research from the 1980s and 1990s, showed that homeless adults compared to non-homeless populations were dying on average in their 40s, outside on the streets, from conditions related to substance use, and were white men.³¹⁻³³ In 1994 Hibbs et al. found the all-cause age-adjusted mortality rate of the general homeless population of Philadelphia to be 3.5 times higher than the general population of that city.³³ In 1997 and 1998 Hwang et al. from Boston Health Care for the Homeless Program (BHCHP) and Harvard T.H. Chan School of Public Health (Harvard Chan School; formerly known as Harvard School of Public Health) showed a similar pattern in that whites, men, and those who have a substance use disorder had a high rate of death.^{34, 35} HIV/AIDS had the highest rate of

death and was the most common cause of death.³⁵ They also found that in addition to HIV/AIDS, renal disease, liver disease, and arrhythmias carried higher risks of death than substance use alone.³⁴ Baggett et al. from BHCHP and Massachusetts General Hospital (MGH) repeated the Hwang et al. 1997 study and found high mortality rates when compared to a non-homeless population but the most common cause of death had shifted from HIV/AIDS to accidental drug overdose.³⁰ The homeless mortality studies since the year 2000 have shown a slightly older average age of death of early 50s.³⁰⁻³⁵ While these aforementioned studies have utilized the general adult homeless population, no study to date has looked at mortality and causes of death among the unsheltered sub-population.

Data on the unsheltered population have been difficult to gather. Despite high visibility on the streets and in public places, as a whole the population is elusive. To care adequately for this vulnerable and often excluded group, engagement is critical and dependent upon consistency, continuity, and time. Studies in the past have usually overlooked the unsheltered population, and the few studies that have focused on unsheltered individuals have been retrospective, cross-sectional, or short term follow-up.^{23,25} No studies to date have examined mortality issues among unsheltered individuals in the U.S. In our study we followed a cohort of 445 unsheltered individuals for 10 years. The data were collected through face-to-face patient encounters by BHCHP's Street Team, a multidisciplinary team begun in 1986 that offers integrated medical and behavioral health care throughout the day and night in Boston directly on the streets to unsheltered homeless adults who eschewed shelters and avoid mainstream clinics. The team's service delivery model of slowly building rapport and caring for people on their own terms allowed the gathering of data for this study.

The objective of this 10-year prospective cohort study was to address the gap in homeless mortality literature. This was accomplished with the following aims: (1) to describe an unsheltered cohort from Boston, MA, from 2000 through 2009 and (2) to compare age-standardized all-cause and cause-specific mortality rates for an unsheltered cohort to the Massachusetts (MA) population from 2000 through 2009 as well as a general homeless cohort Boston, MA from 2003 through 2008. We hypothesized that the unsheltered cohort will have higher all-cause and cause-specific mortality rates than

the non-homeless and general homeless populations and that the unsheltered group would die prematurely from common but preventable and treatable causes of death such as cancer and heart disease as well as substance use and addiction.

METHODS

Study Design and Study Population

We conducted a 10-year prospective study from January 1, 2000 through December 31, 2009. The study population consisted of unsheltered homeless individuals sleeping on the streets of Boston who were patients of BHCHP Street Team. Eligibility criteria were: (1) homeless individuals who were 18 years old or older; (2) sleeping unsheltered on the streets of Boston for one night or more during the calendar year 2000; (3) had at least one face-to-face encounter with a BHCHP Street Team clinician during the calendar year 2000; and (4) were included in the BHCHP Street Team Microsoft® Office Access (Access) database with a first and last name and either a date of birth or a social security number which were necessary for linking data. The database had 568 records. Using the above inclusion criteria 445 unique unsheltered individuals were identified for the cohort. Exclusion criteria were based on lack of identifiable information and age. One hundred and twenty three records with only a first and last name or only a first name were excluded from the analysis. The remaining 445 records were linked and matched to the BHCHP electronic medical record (EMR) to confirm first and last name spellings, date of birth, social security number, gender, and race/ethnicity. The 445 records were then linked and matched to the Massachusetts Department of Public Health (MDPH) death occurrence files to confirm deaths. There were no known duplicates in the cohort and no one was added after December 31, 2000. Everyone in the cohort was alive at the time of enrollment. All cohort members were followed prospectively from their enrollment date until either their date of death or the end of the study on December, 31, 2009. All data on the cohort were collected prospectively and stored in the Access database starting on January 1, 2000, and continuing through December 31, 2009. The study met Boston University Medical Center Institutional

Review Board approval and was assigned study number H-22365, with an Authorization Agreement from Harvard Chan School with assigned study number 16-0357.

Study Context and Setting

The study was conducted at BHCHP with data analyzed at Harvard Chan School. Researchers were from BHCHP, Harvard Chan School, and the University of Toronto. BHCHP is the country's largest and most comprehensive freestanding Health Care for the Homeless program.^{36, 37} The city-wide program was initiated in 1985 and conceived to serve as a catalyst within the mainstream of Boston's hospitals and community health centers, enticing clinicians to venture from traditional clinics and offer direct care in places familiar to homeless persons.^{36, 37} Health care is delivered through a network of accessible clinics at two teaching hospitals, MGH and Boston Medical Center, at over 60 shelters and soup kitchens, on the streets, and in permanent supportive housing.^{36, 37} Multidisciplinary teams of internists, nurse practitioners, physician assistants, psychiatrists, social workers, nurses, and case workers provide integrated medical, behavioral, and oral health care.^{36, 37} Each year the number of unduplicated patients seen has steadily increased from 1,246 in 1985 to 11,097 in 2015.^{36, 37} BHCHP also operates a 24-hour 104-bed medical respite program that provides acute and sub-acute, pre- and post-operative, recuperative and rehabilitative, and palliative and end-of-life care.^{36, 37} The respite program, Barbara McInnis House, had over 2,400 admissions for more than 1,200 unduplicated persons in 2015 who would have otherwise required acute care hospitalizations.^{36, 37}

After founding BHCHP, clinicians and researchers realized that individuals living on the streets and avoiding shelters were not served adequately by either the mainstream medical system or the early BHCHP service delivery model of interconnected clinics in two major teaching hospitals and over 20 adult and family shelters.³⁸ In response to a number of deaths on the streets during 1985-1986, the MDPH contracted with Pine Street Inn (PSI), New England's largest adult homeless shelter, to establish an overnight mobile van.³⁸ Rather than a medical van, the community requested a nightly service that brought food, blankets, and clothing to those sleeping outside. A BHCHP physician rode on the van two nights each week, becoming familiar with the city's unsheltered population and laying the groundwork

for the BHCHP Street Team. Today clinicians from BHCHP's Street Team continue to join the PSI van two nights each week, while the Street Team has grown to include internists, psychiatrists, nurse practitioners and physician assistants, and case workers. Integrated and co-located medical and behavioral health care is offered directly on the night van as well as on the streets during daytime hours to over 500 unduplicated rough sleepers each year. This experience provided the foundation for this study initiated on January 1, 2000.

Data Collection

BHCHP Data

Face-to-face encounters consisted of a Street Team clinician meeting with an unsheltered individual directly on the street during a daytime or nighttime session for medical, behavioral health, or case management care. Street Team clinicians documented the face-to-face encounters on paper while on the street, and later the notes were transcribed by a research assistant into the Access database. Data collected at the initial visit and over time were first name, last name, encounter date, encounter and sleeping location, date of birth, social security number, race/ethnicity, gender, medical and behavioral health diagnoses, and clinician name. As new information became known, such as a last name or date of birth, the Access database was updated. As well, date of death and cause of death were added to the database when a death was known to have occurred or by matching the record to the MDPH death occurrence files or to a National Death Index (NDI) report. At the end of the study, only two variables, social security number and race/ethnicity, had missing data. Fifteen records, or 3.4%, had a missing social security number and seven records, or 1.6%, had an unknown race/ethnicity. For the study, the racial and ethnic categories were defined as: white, black, and other/unknown which contained individuals who identified as American Indian, Hispanic, Asian, or if race/ethnicity was unknown. Three age categories were used: 18-44 years old, 45-64 years old, and 65-84 years old. Gender was a dichotomous variable (man or woman), without any unknowns.

Decedent Data

The primary source for decedent data were the MDPH death occurrences files for the calendar years 2000 through 2009 which was used to confirm the known deaths in the BHCHP Access database as well as to add additional deaths if previously unknown. Only the variables of interest for the study were analyzed from the MDPH data. These were: first name, last name, middle name, maiden name, date of birth, age, social security number, gender, race and ethnicity, referral to medical examiner (ME), autopsy performed, informant relationship (i.e. person informed of the death and person who claimed the body), place of death (i.e. where the death occurred, coded as inpatient, outpatient/emergency department (ED), nursing home, dead on arrival, residence, other, or unknown), veteran status, birth state, address of death, residence address, date of death, underlying cause of death and second through the sixteenth multiple causes of death, all in International Classification of Diseases, Tenth Edition (ICD-10) code format. The other death data were limited reports from the NDI. Over the course of the study, two reports were requested from the NDI on a portion of the cohort for whom whereabouts was unknown at the time. Data extracted from the NDI reports were: underlying cause of death and multiple causes of death also in ICD-10 format, date of death, and state of death.

Cause of Death Definitions and Code Groupings

The underlying causes of death and multiple causes of death data from MDPH and NDI were previously processed by the National Center for Health Statistics (NCHS) using well-established computer algorithms employed to select the underlying cause of death from the list of conditions reported on death certificates.³⁹ The underlying causes of death codes were used to analyze the leading and common causes of death for this study. The codes were grouped based on previous literature.^{30, 35, 40, 41} The Centers for Disease Control and Prevention (CDC) Wide-ranging Online Data for Epidemiologic Research (WONDER) were also used for interpretation of the ICD-10 codes.⁴²

A list of and definitions for the ICD-10 groupings used for this study can be found in the supplemental table. Several of the definitions for the groupings warrant further explanation. *Substance use* was defined as the use of alcohol, the use of drugs in an illicit manner, or the use of a combination of

substances (i.e. polysubstance use).^{40, 43, 44} *Substance Use Disorder* (SUD), representing ICD-10 codes for psychoactive substance use, (F10-19), was defined excessive use of one or more substances, such as alcohol or drugs or a combination of substances.⁴² The SUD category was informed by the CDC WONDER definition of F10-F19 codes and the Diagnostic and Statistical Manual of Mental Disorders-V (DSM-V) which revised the categories of substance abuse and substance dependence from the DSM-IV into one single category called substance use disorder measured on a continuum from mild to severe.⁴⁵ Language has shifted from substance abuse, abuser, and dependence to substance use and substance use disorder representing a clinical and public health movement to change the discourse around addiction and attitudes towards those addicted and away from stigma.⁴⁶ *Drug Overdose* (OD) (*poisoning*), (X40-X49; Y10-Y19), was a grouping of codes from OD attributable to accidental or unintentional poisonings by one or more substances, most often opioids.^{30, 40-42} *Injuries, non-poisoning*, was a grouping representing several external causes death from injuries other than from poisonings and contained *Transportation Accidents* (V01-V99), *Other External Causes of Accidental Injuries* (W00-X59) but excluded codes for accidental poisonings by substances (X40-X49), and *Events of Undetermined Intent* (Y10-Y34) but excluded codes for poisonings from substances of undetermined intent (Y10-Y19).^{30, 40-42}

Matching Data

Link Plus, version 2.0, a probabilistic record linkage program developed at the CDC, Division of Cancer Prevention and Control in support of CDC's National Program of Cancer Registries (NPCR), was used to match the BHCHP data to the MPDH death occurrence data. Each match was manually reviewed. A record was accepted as the same record if they matched on one or more of the following: (1) matching social security number, (2) matching first and last name, and month and year of birth, plus or minus one year, or (3) matching first and last name, month and day of birth.^{30, 35, 39} This algorithm was similar to that used at the NDI to match records and has also been reliably used by previous researchers studying mortality in homelessness populations.^{30, 35, 39} Using the above algorithm, 122 matches from the BHCHP data and the MDPH data were confirmed. An additional 12 records were manually matched from the two

limited NDI reports; these 12 deaths occurred outside of MA. The total number of deaths for the cohort was 134.

Analysis and Study Measures

Descriptive Analysis

Descriptive analysis consisted of tabulating the overall cohort, decedents, men, and women as well as the 2000 census of Boston and MA by age category, race/ethnicity category, and gender.

Additional decedent characteristics collected from the MDPH death occurrence data and NDI reports were tabulated by year of death, place of death, veteran status, informant relationship, and autopsy.

When place of death in the MDPH data were recorded as “residence” or “other,” the address in the MDPH data were reviewed to determine if the address was an apartment or misclassified as a shelter address. The decedent’s BHCHP EMR chart was then reviewed to determine if, at the time of death, the individual was housed in their own apartment or sleeping on the street, in a shelter or “doubling-up” with family or friends. Doubling-up is a term used to imply a homeless person is living with another individual with an apartment or is living with family. The hypothesis was that addresses coded as residence or other in the MDPH data may have been misclassified as the address of a shelter or of a friend or family and not the permanent supportive housing address for the decedent.

The proportion of cases in the cohort and in MA that were referred to and subsequently accepted for further investigation and autopsy by the Office of Chief Medical Examiner (OCME) was also reviewed. A case is referred to and accepted by the OCME when the death was due to violence or natural causes that require further investigation.⁴⁷

Statistical Analysis

All statistical analyses were performed using Stata[®] 14 (StataCorp, College Station, TX) and Microsoft[®] Office Excel 2013. Crude mortality rates for all-cause and cause-specific mortality were calculated using number of deaths in each category divided by person-years of observation for that category to create incident rates. Strata-specific incident rate ratios were calculated by taking one crude mortality rate within a stratum and dividing it by another crude mortality rate within the same stratum.

Age-standardized all-cause and cause-specific mortality rates were calculated using indirect standardization to create standardized mortality ratios (SMR). The unsheltered cohort was used as the standard population and two populations were used as comparison groups: (1) mortality data for the MA population from 2000 through 2009 from CDC WONDER underlying cause of death files and (2) a general homeless cohort from Boston from 2003 through 2008 used by Baggett et al. 2013 in “Mortality Among Homeless Adults in Boston: Shifts in Causes of Death Over a 15-Year Period.”^{30, 42}

The SMRs were calculated by: (1) creating age-specific per person-year mortality rates for the young, middle, and old age categories for MA and the general homeless cohort; (2) multiplying the age-specific per person-year mortality rates by the age-specific person-years from the unsheltered cohort; (3) summing the three age-specific products to determine the expected number of deaths; and (4) dividing the number of observed deaths by the number of expected deaths. SMRs were calculated when the number of deaths in a category was five or more.⁴⁰ Ninety-five percent confidence intervals were calculated for crude mortality rates, rate ratios, and SMRs. Women, whites, and the young age category were used as reference groups. A significance level of less than 0.05 was used for all testing.

Additional Analyses

Dates of death were manually reviewed to determine if the deaths occurred evenly throughout the study and were not clustered. The same was done for the dates of death for causes of death from OD and SUD to determine if these deaths occurred evenly throughout the study. Five goodness of fit tests were completed with chi-squares values calculated to determine if there was a significant difference between the number of deaths observed compared to the number of deaths expected for the year of the study, the four seasons, the day of the week, the month of the year, and the first five days and last five days of the month. The rationale for testing beyond manual review was to ensure there was no significant difference between the numbers of deaths observed versus what would be expected. Since there was some fluctuation in number of deaths by season and sleeping outside in the colder months in New England could increase likelihood of death in later fall or winter, goodness of fit tests for observed versus expected deaths for the four seasons as well as month of the year was warranted.^{33, 35} Also past research has shown

an elevated risk of death from an increase in medical burden from alcohol withdrawal on Sunday going into Monday in places with a history of “blue laws,” a ban on alcohol sales on Sundays.^{33, 35, 48} The blue laws in MA were partially repealed in 2004 allowing liquor stores to sell alcohol under restricted hours; hours for alcohol sales were not expanded until 2014.^{48, 49} Hwang et al. 1997 found an increase in homeless deaths during the first week of the month coinciding with the receipt of entitlement checks.³⁵ Goodness of fit tests were conducted to see if there was a significant difference between the number of deaths observed during the days of the week and the first five days of the month versus what would be expected. The last five days of the month was also examined for significant difference between observed and expected deaths as this is the time when money from entitlements would be exhausted. Without money to buy alcohol, this could also represent a time of increased medical burden from alcohol withdrawal.^{35, 50}

RESULTS

Cohort Characteristics

Using the aforementioned inclusion criteria, 445 people were enrolled in the study. The average age of the cohort at enrollment was 44 years old with a range of 18-81 years old. The average age of death was 53 years old. The average age of death for the adult MA population during the years 2000 to 2009 was 76 years old.⁴² Over two-thirds of the cohort was white (67.2%) and nearly three-quarters were men (72.4%) (Table 1). For Boston in the year 2000, whites were just less than two-thirds (59.5%) and men comprised less than half of the adult population (47.4%). The proportion of those who were over 65 in the cohort was approximately a third of the proportion for Boston (4.7% versus 13.0%). The proportion of blacks in the study (21.1%) was similar to the proportion of blacks in Boston (21.7%).

Decedent Characteristics

A large proportion of the deaths were among men (86.6%) and whites (80.6%) (Table 1). Most of the deaths (65.0%) occurred inside a facility such as an inpatient ward, ED, or nursing home (Table 2); for MA residents the proportion of deaths inside a medical facility was higher by comparison (73.8%).

This difference was largely due to a higher proportion of MA residents dying inside a nursing home than members of the unsheltered cohort (30.0% versus 14.3%); although a higher proportion of cohort deaths occurred inside an ED than the MA residents (16.4% versus 7.3%). Deaths that occurred directly on the streets were found in Place of Death, Other category. For the purposes of this paper, Other category was reported with Place of Death, Residence category. Since the category was called Other, it was difficult to determine the exact number of people who died directly on the street; according to the data from the MDPH, 15 of the deaths were recorded as Other and most likely these occurred outside.

For the cohort, siblings (33.6%), friends or another relationship such as social workers (20.2%), and parents (17.9%) claimed decedents. Compared to the MA population, children (44.5%) most frequently claimed their relatives. Veteran status for the decedents was 8.2% and for MA decedents from 2000 to 2009 it was 21.9%. Both of the proportions for decedent veteran status had high missing or unknown information.

Distribution of Deaths and Place of Death Review

Deaths occurred evenly throughout the 10 years of the study with an average of 13 deaths per year and a range of 9 to 19 deaths per year (Table 2). OD or SUD deaths also occurred evenly throughout the study and were not clustered during the latter half of the study timeframe coinciding with the opioid epidemic (data not shown). Review of addresses where the OD deaths occurred and the BHCHP EMR chart reviews of the decedents who died by OD confirmed that the deaths happened inside someone else's residence, while an unsheltered individual was doubling-up (data not shown).

Goodness of Fit Tests

Chi-squared values for all the goodness of fit tests were less than the values in the chi-square distribution table. Thus there was no significant difference between the observed and the expected number of deaths during year of the study, the four seasons, the month of year, the day of week, or first or last five days of the month.

Autopsy Prevalence

For the unsheltered cohort, 82 (61.2%) decedents were referred to the ME's office for an autopsy and 48 (35.8%) decedents had an autopsy. For eleven (8.2%) decedents, it was unknown if they were referred for or had an autopsy. For MA from 2000 through 2009 there were 138,107 (24.9%) decedents referred for autopsy and 37,206 (6.7%) decedents who had an autopsy. For 13,677 (2.5%) MA decedents, it was unknown if they were referred for or had an autopsy (data not shown).

Mortality Rates

The total person-years for the cohort were 3608.7 with an average of 8.2 person-years and range of 0.1 to 9.9 person-years. The crude mortality rate for the cohort was 3713.2 ((95% confidence interval (CI)) 3110.9, 4397.5) deaths/100,000 person-years (Table 3). The race/ethnicity specific rate ratio (RR) revealed that blacks had a 0.4 (0.2, 0.7) times the rate of death than whites in the study (p-value 0.0001). The RR for other/unknown race/ethnicity showed a 0.5 (0.3, 1.0) times the rate of death compared to whites, but CI includes 1.0. The age-specific RRs (Table 4) for young age were the highest when compared to a non-homeless and general homeless. Age-standardization SMRs showed that the cohort had 9.8 (8.2, 11.5) times the rate of death (Table 5) compared to the MA population and 2.7 (2.3, 3.2) times the rate of death compared to a general homeless cohort.

Causes of Death

The most common causes of death for the unsheltered cohort were: cancer (21), injuries, non-poisoning (19), heart disease (18), SUD (16), and chronic liver disease (15). The highest rate of death when compared to the MA population were from SUD (88.9 (52.7, 141.5)), HIV/AIDS (63.8 (32.4, 113.8)), injuries, non-poisoning (33.3 (20.7, 51.1)), and chronic liver disease (32.2 (18.7, 51.9)). The rate for OD was 14.1 (6.5, 26.7) times higher than MA. The highest rates of death when compared to a general homeless cohort were injuries, non-poisoning (7.1 (4.4, 11.0)), chronic liver disease (4.5 (2.6, 7.3)), SUD (4.2 (2.5, 6.7)), and HIV/AIDS (3.4 (1.7, 6.0)). The rate of OD was not significant when compared to the general homeless cohort. There were too few deaths (less than 5) for several of the causes of death which could not be presented in a table for confidentiality reasons or standardized due to instability of the ratio.

There are 22 deaths not listed in Table 5 as a result. During the 10-year study there were no deaths from diabetes mellitus or tuberculosis and one death from hypothermia which was included in the injury, non-poisoning and too few deaths from suicide or homicide to calculate a mortality rate.

The causes of death related to substance use were SUD (16 deaths), chronic liver disease (15 deaths), and OD (8 deaths); together they summed to 39 deaths and accounted for nearly a third (29.1%) of all the deaths. Fifteen SUD deaths were directly related to alcohol use and one to opioid use. Ten of the chronic liver disease deaths were alcoholic cirrhosis and a review of the multiple causes of death along with the a review of the BHCHP EMR charts for the five remaining chronic liver disease deaths revealed they were related to alcohol use despite being categorized as unspecified liver disease or liver failure. All OD deaths were from opioids use. Thus the rate of death for a combined substance use category (i.e. included codes for SUD, OD, and chronic liver disease found in the cohort) was 43.6 (31.4, 58.9) times greater when compared to MA and 2.5 (1.8, 3.3) times greater when compared to a general homeless cohort.

To further describe the deaths and include the categories for which there were less than five deaths, the deaths were collapsed into four broad categories: noncommunicable diseases (NCD), communicable diseases, conditions directly related to substance use, and acute causes and injuries, non-poisonings (data not shown). The World Health Organization's (WHO) traditional list of four NCDs: cancer, heart disease, chronic lung disease, diabetes, was expanded to include other non-acute NCD found in the study: renal failure, central nervous system disease, mental disorder, diseases of digestive system, cerebrovascular disease.⁵¹ As such 56 (41.8%) of the death could be characterized as NCD deaths. The most common communicable disease was HIV/AIDS for which there were 10 (7.5%) deaths. As described earlier, 39 (29.1%) deaths were directly related to substance use. The remaining 28 (21.0%) deaths were either from acute causes such as sepsis or injuries, non-poisoning such as falls, drownings, and hypothermia.

DISCUSSION

Little is known about the unsheltered adult population in the U.S., and no previous studies have examined all-cause mortality and causes of death for this sub-group of the homeless population. The purpose of this study was to describe an unsheltered cohort in Boston, MA and to calculate age-standardized all-cause mortality rates and age-standardized cause-specific mortality rates for the cohort using two comparison groups. The majority of unsheltered cohort was comprised of white men, as were the decedents. On average the unsheltered cohort died at a younger age than the MA population, 53 versus 76 years and a similar age when compared to the general homeless cohort, 53 versus 51 years.^{30, 42} The age-standardized all-cause mortality rates for the cohort, as a whole and by gender, were high when compared to both the MA population from 2000 through 2009 and to a general homeless cohort from Boston, MA from 2003 through 2008. The age-standardized cause-specific rates for death when compared to MA population were high with only one SMR less than five. When compared to the general homeless cohort, the unsheltered cohort had a two to seven times greater rate of death. All comparisons to the general homeless cohort were statistically significant with the exception of the rate of death from OD which was equivalent. The rate of death from OD for the general homeless cohort in the study by Baggett et al. 2013 was shown to be 16 to 24 times higher for 25 to 44 year olds in the general homeless cohort when compared to MA population.³⁰ For the unsheltered cohort, the most common causes of death were: NCDs, such as cancer (21 deaths) and heart disease (18 deaths); substance use related (39 deaths); injuries, non-poisonings (19 deaths). There were no deaths from diabetes which is commonly found in the U.S. population. There were too few deaths from suicide and homicide to calculate a mortality rate for the unsheltered cohort. Previous homeless mortality research and mortality studies of the U.S. population have found reportable rates of death for both.^{30, 35, 52} There was only one death from hypothermia and none from tuberculosis, causes of death common associated with the homeless population.

The greatest numbers of deaths (56 deaths) were caused by NCDs. When the NCD list was expanded beyond the traditional four diseases, a large number of deaths were found to be from cancer (21 deaths) and heart disease (18 deaths) but also from diseases such as renal failure, chronic lung disease,

and cerebrovascular disease. The primary disparity between the two comparison groups and the unsheltered cohort was not that the cohort was dying from unique or unknown causes of death but that they were dying from causes commonly seen in the general population and they were dying prematurely from these causes. On average, the members of the cohort died decades before they would have, at an average age of death of 53 years old, and they died from treatable and preventable diseases and conditions. This disparity was seen despite the unsheltered cohort having direct access to high-quality integrated medical and behavioral care and access to health insurance.

Early studies on mortality and homelessness showed high all-cause and cause-specific mortality rates and common causes of death were from communicable diseases such as HIV/AIDS and hepatitis as well as substance use related conditions and issues.³¹⁻³⁵ More recent studies have shown that although the all-cause mortality rates for the general homeless population have not decreased, the leading cause of death has shifted away from communicable diseases to only substance use conditions and issues.³⁰ In 2013, Baggett and colleagues found that OD from opioids had emerged as the most frequent cause of death with for general homeless cohort from Boston from 2003 through 2008.³⁰ Baggett et al. 2013 used a six-year retrospective cohort design from 2003 through 2008 and matched members in the cohort to MDPH death occurrence files which was similar to methodology used by Hwang et al. 1997 who used a six-year retrospective study design from 1988 through 1993 and matched records to deaths in Boston.^{30, 35} Hwang et al. 1997 found HIV/AIDS to be the leading cause of death for homeless people 25 to 44 years old in Boston from 1988 through 1993.^{30, 35} Both studies reflect the public health epidemics of each era HIV/AIDS and ODs.^{30, 34, 35} In our study, the mortality rates for HIV/AIDS were still relatively high among rough sleepers when compared to both the MA population and a general homeless cohort, suggesting that prevention and treatment continues to be a challenge for those living outside. Further studies are warranted to determine effective models of care to address these marked health disparities in mortality.

Nearly a third of the deaths were directly related to alcohol, opioids, or a combination of substances, consistent with findings from previous studies.^{30-33, 35} Although in a different population age

group, Auerswald et al. 2016 found that in a street-recruited homeless youth cohort in San Francisco, the majority of deaths were from a combination of suicide and substance use or substance use alone.⁵³ They also found that the mortality rate among street-recruited homeless youths was 10 times higher than the mortality for California's general youth population.⁵³ Schinka et al. 2016 found several variables that were associated with an increased rate of death for older homeless veterans; two of these variables were related to substance use: hospitalization for alcohol use and an alcohol use disorder.⁵⁴ Baggett et al. 2015 quantified tobacco-, alcohol-, and drug-attributable deaths and their contribution to mortality disparities among homeless adults in Boston and found that alcohol-attributable mortality rates were six to 10 times higher, and drug-attributable mortality rates were eight to 17 times higher than MA adults.⁵⁵ In our study the overall rate of death was 9.8 (8.2, 11.5) times greater for the unsheltered cohort when compared to MA and 2.7 (2.3, 3.2) when compared to a general homeless cohort. The rate of death from SUD for the unsheltered cohort was almost 90 times higher when compared to MA and 4.2 (2.5, 6.7) times higher when compared to a general homeless cohort. The combined rate of death from illnesses related substance use (i.e. chronic liver disease, alcohol and drugs) was 43.6 (31.4, 58.9) times greater compared to MA and 2.5 (1.8, 3.3) times greater compared to a general homeless cohort. The results indicate a high prevalence of substance use in the unsheltered cohort as well as a high burden on physical illnesses related to substance use. Additionally many of the deaths from injuries, non-poisonings were indirectly related to substance use, such as falls and drownings that occurred while intoxicated.

Although the deaths from OD were small in number, only eight deaths, the deaths occurred evenly throughout the duration of the study, with an average of one death per year. Our data did not account for non-fatal OD in which the individual did not die but was taken to the ED and/or given Narcan as a rescue. The opioid epidemic in the U.S. escalated dramatically during the timeframe of our study. Approximately 5.3 deaths per 100,000 MA residents from OD occurred in the year 2000 and by 2012 that rate had nearly doubled to 10.1 deaths per 100,000 MA residents from OD.^{56,57} However, the number of deaths from OD in the unsheltered cohort did not increase during the study nor were the deaths from OD

clustered at in the latter five years of the study. Nonetheless the rate of death from OD was 14 times higher for the unsheltered cohort when compared to the adult population of MA.

The OD deaths among the unsheltered cohort all occurred inside a place of residence and not outside on the streets. One explanation for this finding could be that people have been known to engage in riskier behavior when they were in safer environments such as inside someone's home versus on the sidewalk. Bourgois et al. 1997 found that people addicted to opioids tend to inject in social groups rather than alone because of the variable quality of heroin on the streets and the unknown risk of OD.⁵⁸ Drug users say they "never fix alone" to protect against an accidental OD.⁵⁸ Supervised injection services (SISs) have been known to attract the most marginalized groups of drug users, i.e., those without social networks and/or those without safe places to use.⁵⁹ Another explanation for the OD deaths occurring inside could be the OD "high-risk period," the vulnerable time following release from prison or other institutions, or completion of a detoxification and treatment program, including methadone and buprenorphine maintenance.⁶⁰ A large proportion of opiate OD deaths have been shown to occur during this period.⁶⁰ The OD deaths in this study could represent a relapse during a high-risk period since they occurred inside and did not occur on the street, although more research is needed to know for certain.

Whites in the unsheltered cohort died disproportionately to all race/ethnicity categories in the study. Men died disproportionately to women. This finding concurs with results in past studies on mortality among homeless populations as well as previous studies of the general U.S. population, which found that white people living in poverty have high all-cause mortality rates.^{30, 52}

The goodness of fit tests completed were not significant. There was no difference between number of deaths observed compared to number of deaths expected. Past studies have shown a higher number of deaths than expected day of month and day of week.^{33, 35} Reason for the difference in results could be from the effect of changes in laws regulating the sale of alcohol, such as MA blue laws. In this study as well as the Baggett et al. 2013, a high prevalence of autopsies were performed suggesting more accurate underlying causes of death.³⁰ For the unsheltered cohort greater than 50% of the people who claimed the decedent's body were siblings or not family and for the MA population nearly 45% of the

decedents were claimed by their children indicating different social systems for the two populations which warrants further exploration.

Strengths and Limitations

The main strength of the study was that it addressed a crucial gap in homeless literature. Previous studies of mortality among the homeless population have not yet addressed the sub-group of mortality for the unsheltered population, despite the fact that this group comprises almost one-third of the general homeless population.¹ The study design, although observational, was appropriate given the limited literature. Each member of the unsheltered cohort was alive at the time of enrollment, allowing for a temporal sequence between the exposure of sleeping outside and the outcome of death.⁶¹

Another strength of the study was that we were able to use two comparison groups. We compared the unsheltered cohort to a non-homeless population as well as a general homeless cohort from Boston. The general homeless cohort was from the same city and had access to BHCHP clinics. The MA population although not served by BHCHP, had access to health insurance; during the study timeframe 93 to 97% of MA residents had health insurance.⁴⁴ Everyone included in the study had access to an integrated medical and behavioral health outreach program. The findings were less likely to be due to lack of health care or lack of access to care. No one in the study was refused care based on insurance or homeless status.

All unsheltered individuals seen and served by the BHCHP Street Team in Boston during the year 2000 were enrolled in the study; sampling was not employed. Enrolling all patients seen by the Street team during the year 2000 may not have been exhaustive and some individuals sleeping outside may not have been seen by the team during time of enrollment, and could be seen as a limitation; thus creating the potential for a selection bias towards those who sought medical and behavioral health services on the streets.⁶² Given the smaller size of the City of Boston and the extensive network of day and night outreach services provided by the Street Team and their community partners, the number of individuals not included in the study was likely to be small. Similarly if a patient was enrolled in the study and later traveled to and died in another state, the death would not have been recorded in the MDPH death

occurrence files, our primary source of death data, and thus probably not included in our dataset. If this occurred, it would represent non-differential lost to follow-up and would bias the results toward null.⁶²

This could also be seen as selection bias in that the people who entered the cohort and then traveled to and died in another state might be systematically different from the people who stayed and/or died in MA.⁶²

We could address any concern for attrition, a common issue with prospective cohort studies, and selection bias in the future by obtaining NDI records for those considered alive at the end of this study.

Likewise, the 123 unknowns for which we had only first name or first and last name could be systematically different from the rest of the cohort; specifically they could have experienced unsheltered homelessness for a shorter time and the Street Team clinicians were unable to build a rapport with them to adequately learn their identity. When encountering a person living outside, it takes time for Street Team clinicians to build a rapport with each individual. As a result most people, even with severe mental illness, became well known to the team. Alternatively the unknowns could be duplicates of the identified members of the cohort; that is when identifiers were learned for a patient from the street, a new record was opened instead of the current one being updated. In maintaining the database used for this study, all attempts were made to confirm the identifiers for the individuals included in the analysis by comparing the Access database records to that in the BHCHP EMR to conform name spelling, date of birth, and social security.

Another limitation of the study was that the dataset did not have a variable to account for the length of time homeless before or during the study, which perhaps could affect someone's rate of dying. The entire cohort was homeless at the time of enrollment. Accounting for length of time homeless should be included in future homelessness mortality research. A further limitation of the study was that some of the causes of death were rare for the cohort or few in number. In these instances, it was not possible to calculate the cause-specific mortality rates as the rate was unstable. This could be addressed in the future by using a larger cohort if possible. A limitation of all studies utilizing death data are that the underlying cause of death is dependent on the person filling out the death certificate and can be unreliable and subject to error and variability.⁶³

The unsheltered individuals in our study most likely resembled unsheltered individuals in urban areas across the U.S., but some variability is likely from city to city across the country. Boston has guaranteed each homeless person a bed in a shelter.¹⁶⁻¹⁸ Thus the people sleeping outside in Boston, in some respects, have chosen not to access a shelter. In another city without the same policy an unsheltered person given the option, might choose the shelter. Although the exposure of sleeping rough was probably the same for both situations, more research is warranted. Another aspect that could affect the generalizability is the direct access to health insurance and health care in MA. The unsheltered individuals in the study had access to integrated health care regardless of insurance status. Since access to health insurance and health care is not uniform across the U.S., particularly during the time period of this study, mortality could be influenced by inability to obtain care when needed.

Future research

Future research is needed in several areas. Accurately assessing the chronicity of homelessness, as well as length of time sleeping outside, will help better determine mortality rates and causes of death for those sleeping chronically on the streets of urban cities. Conducting lifecourse studies, if data are available, is warranted to better understand the predictors of morbidity and mortality for the unsheltered and other homeless sub-populations. Research should focus on the social determinants of unsheltered homelessness, such as shelter system rules and regulations and to what extent harm-reduction models are or have been employed, education level obtained, history of incarceration, history of foster care and any instability during childhood, to understand how to address the needs of this population. As well, there should be studies of where the unsheltered population use drugs to reveal areas for future interventions to decrease deaths and near deaths from OD.

Mortality outcomes for the unsheltered cohort were worse than a non-homeless population and a general homeless cohort despite having access to a patient-centered service delivery model of care. Comparing unsheltered homeless mortality outcomes from Boston to outcomes for the unsheltered population in other cities or regions in the U.S. could inform what is needed within and beyond a medical

and behavioral health service delivery model of care to ultimately improve outcomes for this vulnerable population.

CONCLUSION

Unsheltered individuals are a sub-group of the homeless population that is not only difficult to engage in health care but also elusive and challenging to study.^{5, 23} Our study, the first to examine all-cause and cause-specific mortality rates among the unsheltered population in the U.S., showed that those sleeping rough had an all-cause mortality rate that was almost three times greater than a general homeless cohort from Boston, a finding not previously reported. Cause-specific mortality rates were 2.4 to 7.1 times greater for the unsheltered compared to a general homeless cohort, a significant disparity also not known previously. In addition, when compared to the MA population, the unsheltered cohort had an almost 10 times greater rate of dying from all causes and a 4.8 to nearly 90 times greater rate for specific causes of death. The social determinants of health attendant to the abject poverty experienced by the unsheltered cohort overwhelmed the benefit of health insurance and access to a patient-centered service delivery model that brought high-quality medical and behavioral health care directly to the street. The unsheltered cohort died prematurely from common causes of death, many of which were preventable and treatable. An understanding of the social and supportive services necessary to augment clinical service delivery models are needed if the health outcome disparities borne by those sleeping outside are to be addressed in the future. This understanding will have implications for clinicians, policy makers, and public health workers. Research aimed at understanding the social determinants, such as understanding the role of harm-reduction models in a homeless shelter system as well as learning more about individual level information such as education attainment and behavioral health issues, for the unsheltered population is imperative to inform future policies and interventions that will reduce not only morbidity and mortality for the unsheltered population but eliminate unsheltered homelessness and homelessness overall.

TABLES

Table 1-1: Characteristics of the Unsheltered Cohort from 2000-2009

	Cohort N = 445	Men N = 322	Women N = 123	Decedents N = 134	Boston 2000 Census ≥18 years old N = 472,582 ^a	MA ^b 2000 Census ≥18 years old N = 4,849,033 ^c
Characteristic	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Age (years)						
18-44	248 (55.7)	165 (51.2)	83 (67.5)	56 (41.8)	306,658 (64.9)	2,569,111 (53.0)
45-64	176 (39.6)	140 (43.5)	36 (29.3)	65 (48.5)	104,588 (22.1)	1,419,760 (29.3)
≥65	21 (4.7)	17 (5.3)	4 (3.3)	13 (9.7)	61,336 (13.0)	860,162 (17.7)
Race/Ethnicity						
White	299 (67.2)	223 (69.3)	76 (61.8)	108 (80.6)	283,109 (59.9)	4,180,644 (86.1)
Black	94 (21.1)	62 (19.3)	32 (26.0)	15 (11.2)	102,491 (21.7)	236,027 (4.9)
^d Other/Unknown	52 (11.7)	37 (11.5)	15 (12.2)	11 (8.2)	86,982 (18.4)	432,362 (8.9)
Gender^e						
Men	322 (72.4)			116 (86.6)	224,078 (47.4)	2,289,671 (47.2)
Women	123 (27.6)			18 (13.4)	248,504 (52.6)	2,559,362 (52.8)

^a Number reflects data on individuals ≥18 years old from Boston for the year 2000 from US Census Bureau: <http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml>

^b MA refers to Massachusetts

^c Number reflects data on individuals ≥18 years old from Massachusetts for the year 2000 from US Census Bureau:

<http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml>

^d Other Race/Ethnicity category contains individuals who reported their race/ethnicity to be American Indian, Hispanic, Asian, or race/ethnicity was unknown

^e No missing data for Gender

Table 1-2: Additional Characteristics of 134 Unsheltered and Massachusetts Decedents from 2000-2009

Characteristic	Unsheltered Decedents	Massachusetts Decedents ^a
Place of Death	N (%)	N (%)
Inpatient	46 (34.3)	202484 (36.5)
Emergency Department	22 (16.4)	40597 (7.3)
Nursing Home	19 (14.3)	166415 (30.0)
Residence/Other	35 (26.1)	136581 (24.6)
Dead on Arrival	5 (3.7)	8182 (1.5)
Unknown	7 (5.2)	812 (0.1)
Informant Relationship		
Sibling	45 (33.6)	43181 (7.8)
Friend/Other	27 (20.2)	25669 (4.6)
Parent	24 (17.9)	27845 (5.0)
Child	18 (13.4)	246942 (44.5)
Extended Family	5 (3.7)	42279 (7.6)
Spouse	4 (3.0)	168102 (30.3)
Unknown	11 (8.2)	1053 (0.2)
Veteran Status		
Any Military	11 (8.2)	121791 (21.9)
No Military	6 (4.5)	76556 (13.8)
Unknown	117 (87.3)	356724 (64.3)
Year of Death^b		
2000	16 (11.9)	
2001	18 (13.4)	
2002	11 (8.2)	
2003	19 (14.2)	
2004	15 (11.2)	
2005	12 (9.0)	
2006	13 (9.7)	
2007	11 (8.2)	
2008	10 (7.5)	
2009	9 (6.7)	

^aMassachusetts data from Massachusetts Department of Public Health Death Occurrence files for the years 2000 to 2009

^bNo missing data for Year of Death

Table 1-3: Age Specific, Race/Ethnicity Specific, & Gender Specific Rate Ratios for Unsheltered Cohort, 2000-2009

				Mortality Rate Deaths/100,000 Person-years (95% CI) ^a	Rate Ratio (95% CI)	p-value (0.05)
Overall		Deaths	Person-years	3713.2 (3110.9, 4397.5)		
Age (years)						
	18-44	56	2124.6	2635.8 (1990.7, 3422.2)	1.0	
	45-64	65	1350.3	4813.8 (3716.0, 6136.9)	1.6 (1.1, 2.2)	0.0091
	65-84	13	133.8	9715.9 (5165.6, 16589.9)	2.8 (1.4, 5.0)	0.0020
Race/Ethnicity						
	White	108	2325.2	4644.7 (3810.5, 5608.3)	1.0	
	Black	15	835.4	1795.5 (1005.4, 2962.9)	0.4 (0.2, 0.7)	0.0001
	^b Other/Unknown	11	448.1	2455.1 (1225.7, 4393.3)	0.5 (0.3, 1.0)	0.0321
Gender ^c						
	Women	18	1130.6	1592.1 (943.2, 2515.3)	1.0	
	Men	116	2478.1	4681.0 (3868.2, 5614.7)	2.9 (1.8, 5.1)	<0.0001

^a CI refers to Confidence Interval^b Other Race/Ethnicity category contains individuals who reported their race/ethnicity to be American Indian, Hispanic, Asian, or race/ethnicity was unknown^c No missing data for Gender

Table 1-4: Age Specific Rate Ratios for Unsheltered Cohort, 2000-2009 Compared to Massachusetts Population, 2000-2009 and to General Homeless Cohort from Boston, MA, 2003-2008^a

Age (years)	Unsheltered Cohort Deaths	Mortality Rate/100,000 PY ^b (95% CI) ^c	MA ^d Deaths	Mortality Rate/100,000 Pop. (95% CI)	RR ^e (95% CI) Unsheltered vs. MA	General Homeless Deaths	Mortality Rate/100,000 PY (95% CI)	RR (95% CI) Unsheltered vs. General Homeless
18-44	56	2635.8 (1990.7, 3422.2)	26198	105.6 (104.3, 106.9)	25.0 (18.9, 32.4)	365	738.6 (664.7, 818.4)	3.6 (2.6, 4.7)
45-64	65	4813.8 (3716.0, 6136.9)	84036	521.3 (517.8, 524.8)	9.2 (7.1, 11.8)	796	2137.6 (1991.7, 2291.4)	2.3 (1.7, 2.9)
65-84	13	9715.9 (5165.6, 16589.9)	243241	3319.5 (3306.4, 3332.7)	2.9 (1.6, 5.0)	136	3668.5 (3078.1, 4339.7)	2.6 (1.4, 4.7)
All Ages	134	3713.2 (3110.9, 4397.5)	353475	732.4 (730.0, 734.8)		1297	1435.3 (1358.3, 1515.6)	

^a General Homeless Cohort from Boston, MA, 2003-2008 used for comparison from Baggett, TP et al. *Mortality Among Homeless Adults in Boston: Shifts in Causes of Death Over a 15-Year Period*. JAMA 2013 Feb; 173 (3): 189-195

^b PY refers to Person-years

^c CI refers to Confidence Interval

^d MA refers to Massachusetts

^e RR refers to Rate Ratio

Table 1-5: All-Cause and Cause-Specific Age-Standardized Mortality Ratios for the Unsheltered Cohort, 2000-2009 Compared to the Massachusetts Population, 2000-2009 and to a General Homeless Cohort from Boston, MA, 2003-2008^a

Underlying Cause of Death ^{b*}	N=134 (%)	SMR ^c (95% CI ^d) Unsheltered vs. MA ^e	SMR (95% CI) Unsheltered vs. General Homeless	Autopsy N=48	Facility Death ^f N=87
All-Cause					
Entire Cohort	134 (100)	9.8 (8.2, 11.5)	2.7 (2.3, 3.2)	48	87
Men	116 (86.6)	9.2 (7.6, 11.0)	2.9 (2.4, 3.4)	41	73
Women	18 (13.4)	6.5 (4.0, 10.1)	2.0 (1.2, 3.0)	7	14
Natural Causes					
Cancer	21 (15.7)	4.8 (3.1, 7.3)	2.8 (1.8, 4.2)	1	18
Heart Diseases	18 (13.4)	6.4 (3.9, 9.9)	2.4 (1.4, 3.7)	5	9
Substance Use Disorder	16 (11.9)	88.9 (52.7, 141.5)	4.2 (2.5, 6.7)	9	5
Chronic Liver Disease	15 (11.2)	32.2 (18.7, 51.9)	4.5 (2.6, 7.3)	6	9
HIV/AIDS	10 (7.5)	63.8 (32.4, 113.8)	3.4 (1.7, 6.0)	0	8
Ill-defined Conditions	5 (3.7)	26.8 (9.8, 59.3)		4	4
External Causes					
Injuries, non-poisoning ^g	19 (14.2)	33.3 (20.7, 51.1)	7.1 (4.4, 11.0)	13	14
Drug Overdose (poisoning)	8 (6.0)	14.1 (6.5, 26.7)	0.9 (0.4, 1.7) [†]	6	2
Substance Use Causes					
Substance Use	39 (29.1)	43.6 (31.4, 58.9)	2.5 (1.8, 3.3)	21	16
Alcohol	30 (22.4)	110.2 (75.7, 155.3)		14	13
Opioid	9 (6.7)	15.7 (7.6, 28.8)		7	3

^a General Homeless Cohort from Boston, MA, 2003-2008 used for comparison from Baggett, TP et al. *Mortality Among Homeless Adults in Boston: Shifts in Causes of Death Over a 15-Year Period*. JAMA 2013 Feb; 173 (3): 189-195

^b No unknown Causes of Death

^c SMR refers to Standardized Mortality Ratio and were calculated when there were ≥5 deaths for a specific cause

^d CI refers to Confidence Interval

^e MA refers to Massachusetts

^f Facility Death refers to deaths that occurred in medical facilities (i.e. inpatient ward, outpatient clinic, emergency department, nursing home)

^g Injuries, non-poisoning category contains Transportation Accidents codes V01-V99, Other External Causes of Accidental Injuries codes W00-X59 except for X40-X49 which represent accidental poisonings by noxious substances, and Events of Undetermined Intent codes Y20-Y34 except for codes Y10-Y19 which represent poisonings of undetermined intent. Methodology in collapsing ICD-10 categories based on similar methodology in Health of Boston 2014-2015 Report from the Boston Public Health Commission: http://www.bphc.org/healthdata/health-of-boston-report/Documents/HOB-2014-2015/FullReport_HOB_2014-2015.pdf

* Causes of death <5 were suppressed and do not appear in the table; these causes were: Diseases of Digestive System, Pneumonia, Chronic Lower Respiratory Disease, Sepsis, Viral Hepatitis, Anoxic Brain Injury, Cerebrovascular Disease, Renal Failure, Central Nervous System Disease, Mental Disorder, Suicide, Homicide

[†] SMR not significant at <0.05 level; all SMRs without symbol were significant at <0.05

Supplemental Table: International Classification of Diseases 10th Revision (ICD-10) Codes Used and Definitions of Causes of Death			
Underlying Cause of Death ^a	ICD-10 Codes Range	ICD-10 Codes from Unsheltered Cohort	Definitions
Natural Causes			
Infection (Sepsis, Viral Hepatitis)	A30-A49, B90-B94	A41, B94	Acute infectious disease
HIV/AIDS disease	B20-B24	B20, B22, B23, B24	Symptomatic HIV/AIDS disease, not asymptomatic disease
Cancer	C00-C97	C15, C18, C20, C26, C32, C34, C41, C55, C61, C79, C85	Malignant neoplasms only, not benign tumors
Mental Disorders	F01-F09	F09	Primary and secondary symptomatic mental disorders
Substance Use Disorder	F10-F19	F10-F11	Death from the use of one or more substances such as alcohol or opioids
Central Nervous System Disease	G10-G14	G10	Central nervous system disease from atrophies
Anoxic Brain Injury	G90-G98	G93	Nervous system disorders including brain injuries
Heart Disease	I00-I51	I11, I21, I24-I25, I27, I42, I46, I50	All diseases involving the heart, not cerebrovascular related
Cerebrovascular Disease	I60-I69	I61, I64	All cerebrovascular related diseases, excluded heart disease
Influenza and Pneumonia	J09-J18	J15, J18	Influenza from influenza virus and/or all acquired pneumonias
Chronic Lower Respiratory Disease	J40-J47	J44	Chronic Lower Respiratory Disease including bronchitis and Chronic Obstructive Pulmonary Disease
Diseases of Digestive System	K00-K66, K80-K92	K55, K62, K92	Digestive system disease including vascular disorders, prolapse, and unspecified
Chronic Liver Disease	K70-K76	K70, K72, K74, K76	Alcoholic and toxic liver disease, hepatic failure, chronic hepatitis, fibrosis and cirrhosis, excluded viral hepatitis
Renal Failure	N17-N19	N18-N19	Renal failure due to congenital or exogenous causes
Ill-Defined Conditions	R00-R99	R62, R99	Clinical findings and diseases not classified elsewhere
External Causes			
Injuries, non-poisoning	V01-V99, W00-X39, X50-X59, Y20-Y34	W05, W10, W19, W74, W80, X31, X59, V03, V05, V09, V29, Y21, Y31, Y34	Death from injuries other than from poisonings
Drug Overdose (poisoning)	X40-X49, Y10-Y19	X42, X44, Y12, Y14	Death from overdose attributable to poisonings by one or more substances of abuse such as alcohol or opioids
Suicide	X60-X84	X71	Death from Intentional self-harm
Homicide	X85-Y09	X99, Y09	Death from assault
Additional Groupings			
Substance Use	F10-F19, K70, X40-X49, Y10-Y19	F10-F11, K70, X42, X44, Y12, Y14	Deaths from the use of one or more substances of abuse, including overdose from poisonings
Alcohol	F10, K70, X45, Y15	F10, K70-K76	Deaths attributable to the use of alcohol, including poisoning from alcohol
Opioids	F11, F19, X42-X44, Y12-Y14	F11, X42, X44, Y12, Y14	Deaths attributable to the use of opioids, including overdose poisoning from opioids

^a No unknown Causes of Death

PAPER TWO

**Relative Survival of Rough Sleepers: survival analysis of an unsheltered adult homeless cohort
from Boston, MA, 2000 through 2009**

ABSTRACT

Purpose: This paper addressed a gap in homeless mortality literature by determining the relative survival of an unsheltered cohort from Boston, MA, from 2000 through 2009.

Methods: A 10-year prospective study was conducted from January 1, 2000, through December 31, 2009, with 445 unique unsheltered adults who were patients of Boston Health Care for the Homeless Program's Street Team, an integrated medical and behavioral health outreach program. Survival analysis included: age-stratified Kaplan-Meier Survival Estimate curves; age-stratified Log-Rank Tests for Equality; and Cox Proportional Hazard Models with Likelihood Ratio Tests.

Results: During the study, 134 deaths occurred. More than two-thirds of the cohort was white and almost three-quarters were men. Similarly, more than 80% of the decedents were white, and more than 86% men. The Kaplan-Meier Survival Estimates showed low probabilities of survival at five years and 10 years for all age-stratified curves. All Log-Rank Tests for Equality were statistically significant. The Cox Proportional Hazard Models revealed high rates of mortality for middle and old age groups as well as for men, and low rates of mortality for non-white race/ethnicity.

Conclusions: The unsheltered cohort had high rates for mortality and low probabilities of survival; whites, men, and older age groups had the highest rate for mortality and lowest survival. These results were seen despite near-universal insurance in Massachusetts and direct access to a patient-centered medical and behavioral health service delivery model of care that met the unsheltered population on the streets of Boston. Future studies are warranted to further understand these health disparities and the social determinants for the unsheltered population to create the necessary health care, housing, and supportive social services necessary to improve the morbidity and mortality outcomes for this group as well as to decrease unsheltered homelessness.

INTRODUCTION

The few studies on mortality among the homeless population have been mostly limited to the general homeless population; no study to date has described the relative survival of the homeless population in the United States (U.S.). The general homeless population has been shown to die prematurely with relatively high rates of death caused by preventable and treatable conditions.³⁰⁻³⁵ In 1987, the Atlanta Medical Examiner's (ME) office reviewed 40 homeless deaths and found the mean age of death to be 44 years old.³¹ Most of the deaths were directly related to alcohol use.³¹ In 1991, the San Francisco Department of Public Health's Health Care for the Homeless Program reviewed 644 records of homeless decedents from the city ME's office that occurred over a six year period.³² The mean age at death was 41 years old.³² Most decedents were white men, most deaths were related to substance use and most deaths occurred outside.³² Hwang et al. 1997 found an average age of death of 47 years old in a general homeless cohort from Boston during a six-year retrospective study from 1988 through 1993.³⁵ The highest mortality rates were due to HIV/AIDS, reflecting the effects of the HIV/AIDS epidemic on the homeless population.³⁵ Fifteen years later, using a homeless cohort from Boston from 2003 through 2008, Baggett et al. 2013 repeated Hwang et al. earlier mortality study.^{30, 35} The mean age of death had risen to 51 years old.³⁰ While mortality rates remained higher than a non-homeless comparison population, the leading cause of death shifted to drug overdose (OD), which suggested that the HIV/AIDS epidemic had been replaced by the opioid epidemic in the homeless population.³⁰ As in previous homeless mortality studies, the majority of decedents in the Hwang and Baggett studies were white men.^{30, 35}

No previous study of mortality and homelessness has conducted survival analysis. To date, only one previous study examined the mortality of an unsheltered cohort in the U.S.⁶⁴ Using an unsheltered cohort, Roncarati et al. found an average age of death of 53 years old with high all-cause and cause-specific mortality rates for the unsheltered cohort when compared to both a non-homeless population and a general homeless cohort.⁶⁴

Unsheltered individuals who are 18 years or older and unaccompanied by family account for almost a third of the homeless population in the U.S., the majority of whom are white and men.¹ On a

single night in January 2015, 564,708 were counted as homeless in the U.S., 358,422 were counted as homeless individuals and 152,806, (43% of the number of individuals and 31% of the homeless population), unsheltered individuals, of whom 57.1% were white and 74.0 % men.¹ Despite high visibility on the streets of U.S. cities, the sub-group of unsheltered individuals remains elusive and little is known about their lives and deaths. Understanding the demographics and health status of the unsheltered population is necessary to inform policy at the local, state, and national level that can address the special needs of those sleeping outside or even prevent it from occurring. This study seeks to further address the gap in mortality and homelessness literature by examining the relative survival for an unsheltered cohort from Boston from 2000 through 2009.

Understanding the unsheltered population has been difficult. They are an elusive group, prone to paranoia and mistrust. This study used data obtained from face-to-face encounters with unsheltered individuals by Boston Health Care for the Homeless Program's (BHCHP) Street Team, a multidisciplinary team who has scoured the streets of Boston day and night since 1986 to offer direct access to medical and behavioral health care to those sleeping on park benches, in doorway, under bridges, and in city parks.^{36,37} Trust and rapport has been and still is fostered with those living outside by a continuity of presence.

Survival analysis included age-stratified Kaplan-Meier Survival Estimate curves, age-stratified Log-Rank Tests for Equality, and Cox Proportional Hazard Models with Likelihood Ratio Tests. The overall hypotheses were (1) probabilities of survival would be low at five and 10 years and (2) outcomes would differ by gender and race/ethnicity as previous homeless mortality research has shown a higher mortality for white men.

METHODS

Study Design and Study Population

We conducted a 10-year prospective study from January 1, 2000 through December 31, 2009. The study population consisted of unsheltered homeless individuals sleeping on the streets of Boston who

were patients of BHCHP Street Team. Eligibility criteria were: (1) homeless individuals who were 18 years old or older; (2) sleeping unsheltered on the streets of Boston for one night or more during the calendar year 2000; (3) had at least one face-to-face encounter with a BHCHP Street Team clinician during the calendar year 2000; and (4) were included in the BHCHP Street Team Microsoft® Office Access (Access) database with a first and last name and either a date of birth or a social security number which were necessary for linking data. The database had 568 records. Using the above inclusion criteria 445 unique unsheltered individuals were identified for the cohort. Exclusion criteria were based on lack of identifiable information and age. One hundred and twenty three records with only a first and last name or only a first name were excluded from the analysis. The remaining 445 records were linked and matched to the BHCHP electronic medical record (EMR) to confirm first and last name spellings, date of birth, social security number, gender, and race/ethnicity. The 445 records were then linked and matched to the Massachusetts Department of Public Health (MDPH) death occurrence files to confirm deaths. There were no known duplicates in the cohort and no one was added after December 31, 2000. Everyone in the cohort was alive at the time of enrollment. All cohort members were followed prospectively from their enrollment date until either their date of death or the end of the study on December, 31, 2009. All data on the cohort were collected prospectively and stored in the Access database starting on January 1, 2000, and continuing through December 31, 2009. The study met Boston University Medical Center Institutional Review Board approval and was assigned study number H-22365, with an Authorization Agreement from Harvard Chan School with assigned study number 16-0357.

Study Context and Setting

The study was conducted at BHCHP with data analyzed at Harvard Chan School. Researchers were from BHCHP, Harvard Chan School, and the University of Toronto. BHCHP is the country's largest and most comprehensive freestanding Health Care for the Homeless program.^{36, 37} The city-wide program was initiated in 1985 and conceived to serve as a catalyst within the mainstream of Boston's hospitals and community health centers, enticing clinicians to venture from traditional clinics and offer direct care in places familiar to homeless persons.^{36, 37} Health care is delivered through a network of accessible clinics

at two teaching hospitals, Massachusetts General Hospital and Boston Medical Center, at over 60 shelters and soup kitchens, on the streets, and in permanent supportive housing.^{36,37} Multidisciplinary teams of internists, nurse practitioners, physician assistants, psychiatrists, social workers, nurses, and case workers provide integrated medical, behavioral, and oral health care.^{36, 37} Each year the number of unduplicated patients seen has steadily increased from 1,246 in 1985 to 11,097 in 2015.^{36,37} BHCHP also operates a 24-hour 104-bed medical respite program that provides acute and sub-acute, pre- and post-operative, recuperative and rehabilitative, and palliative and end-of-life care.^{36, 37} The respite program, Barbara McInnis House, had over 2,400 admissions for more than 1,200 unduplicated persons in 2015 who would have otherwise required acute care hospitalizations.^{36, 37}

After founding BHCHP, clinicians and researchers realized that individuals living on the streets and avoiding shelters were not served adequately by either the mainstream medical system or the early BHCHP service delivery model of interconnected clinics in two major teaching hospitals and over 20 adult and family shelters.³⁸ In response to a number of deaths on the streets during 1985-1986, the MDPH contracted with Pine Street Inn (PSI), New England's largest adult homeless shelter, to establish an overnight mobile van.³⁸ Rather than a medical van, the community requested a nightly service that brought food, blankets, and clothing to those sleeping outside. A BHCHP physician rode on the van two nights each week, becoming familiar with the city's unsheltered population and laying the groundwork for the BHCHP Street Team. Today clinicians from BHCHP's Street Team continue to join the PSI van two nights each week, while the Street Team has grown to include internists, psychiatrists, nurse practitioners and physician assistants, and case workers. Integrated and co-located medical and behavioral health care is offered directly on the night van as well as on the streets during daytime hours to over 500 unduplicated rough sleepers each year. This experience provided the foundation for this study initiated on January 1, 2000.

Data Collection

BHCHP Data

Face-to-face encounters consisted of a Street Team clinician meeting with an unsheltered individual directly on the street during a daytime or nighttime session for medical, behavioral health, or case management care. Street Team clinicians documented the face-to-face encounters on paper while on the street, and later the notes were transcribed by a research assistant into the Access database. Data collected at the initial visit and over time were first name, last name, encounter date, encounter and sleeping location, date of birth, social security number, race/ethnicity, gender, medical and behavioral health diagnoses, and clinician name. As new information became known, such as a last name or date of birth, the Access database was updated. As well, date of death and cause of death were added to the database when a death was known to have occurred or by matching the record to the MDPH death occurrence files or to a National Death Index (NDI) report. At the end of the study, only two variables, social security number and race/ethnicity, had missing data. Fifteen records, or 3.4%, had a missing social security number and seven records, or 1.6%, had an unknown race/ethnicity. For the study, the racial and ethnic categories were defined as: white, black, and other/unknown which contained individuals who identified as American Indian, Hispanic, Asian, or if race/ethnicity was unknown. Three age categories were used: 18-44 years old, 45-64 years old, and 65-84 years old. Gender was a dichotomous variable (man or woman), without any unknowns.

Decedent Data

The primary source for decedent data were the MDPH death occurrences files for the calendar years 2000 through 2009 which was used to confirm the known deaths in the BHCHP Access database as well as to add additional deaths if previously unknown. Only the variables of interest for the study were analyzed from the MDPH data. These were: first name, last name, middle name, maiden name, date of birth, social security number, gender, race and ethnicity, and date of death. The other death data were limited reports from the NDI. Over the course of the study, two reports were requested from the NDI on a portion of the cohort for whom whereabouts was unknown at the time. Data extracted from the NDI

reports were: first name, last name, date of birth, social security number, gender, race and ethnicity, and date of death.

Matching Data

Link Plus, version 2.0, a probabilistic record linkage program developed at Centers for Disease Control and Prevention (CDC), Division of Cancer Prevention and Control in support of CDC's National Program of Cancer Registries (NPCR), was used to match the BHCHP data to the MPDH death occurrence data. Each match was manually reviewed. A record was accepted as the same record if they matched on one or more of the following: (1) matching social security number, (2) matching first and last name, and month and year of birth, plus or minus one year, or (3) matching first and last name, month and day of birth.^{30, 35, 39} This algorithm was similar to that used at the NDI to match records and has also been reliably used by previous researchers studying mortality in homelessness populations.^{30, 35, 39} Using the above algorithm, 122 matches from the BHCHP data and the MDPH data were confirmed. An additional 12 records were manually matched from the two limited NDI reports; these 12 deaths occurred outside of Massachusetts. The total number of deaths for the cohort was 134.

Statistical Analysis and Study Measures

Descriptive analysis consisted of tabulating the overall cohort, decedents, men, women, and the 2000 census of Boston and MA by age category, race/ethnicity category, and gender. All statistical analyses were performed using Stata[®] 14 (StataCorp, College Station, TX) and Microsoft[®] Office Excel 2013. Survival analysis consisted of creating age-stratified Kaplan-Meier Survival Estimate curves for age, gender, and race/ethnicity, conducting age-stratified Log-Rank Tests for Equality for age, gender, and race/ethnicity and calculating Cox Proportional Hazard Models. The variables of interest for survival analysis were age, gender, race/ethnicity, date of enrollment, and date of death. Time until death was modeled using three Cox Proportional Hazard Models. Model one contained all variables. Model two was run without age and model three was run without race/ethnicity. Significance of multi-category prediction (i.e. age and race/ethnicity) was assessed using a Likelihood Ratio Test. Women, whites, and young age category were used as reference groups. A significance level of less than 0.05 was used for all testing.

RESULTS

Cohort Characteristics

During the year 2000, 445 unsheltered individuals met the eligibility criteria and were enrolled into the study. Of these individuals, 134 died over the course of the study. Greater than two-thirds of the cohort were white (67.2%) and almost three-quarters were men (72.4%). Similarly, the decedents were over 80% white and over 86% men. The average age of the cohort at enrollment was 44 years old with a range of 18-81. The average age of death was 53 years old with a range of 28-82. Deaths occurred evenly throughout the 10 years of the study with an average of 13 deaths per year and a range of 9-19 deaths per year (data not shown). The cohort had 3608.7 person-years with a crude mortality rate of 3713.2 ((95% confidence interval (CI)) 3110.9, 4397.5) deaths per 100,000 person-years (data not shown).

Survival Analysis

Kaplan-Meier Survival Estimate Curves and Log-Rank Tests for Equality

Figures 1-4 depict the Kaplan-Meier Survival Estimate curves and the Log-Rank Tests for Equality results. All Log-Rank Tests conducted were statistically significant. By five years almost 25% of the cohort had died and by 10 years more than a third had died (Fig.1). Unsheltered individuals who were middle age or older, white, and men had the lowest probabilities of survival (Fig 2-4). Fig.3 depicts more than a quarter of middle age men were deceased at five years and about a third were deceased by 10 years and more than a half of old age men are deceased at five years and about two thirds at 10 years. In Fig.4 illustrated that nearly a quarter of white middle age individuals were deceased at five years and one third at 10 years; for old age whites, more than a half were deceased by five years and all were deceased by 10 years.

Cox Proportional Hazard Model and Likelihood Ratio Tests

The middle age group and the old age group both had Hazard Ratios that were higher than the young age group (Table 2). Blacks had a 0.4 (0.3, 0.7) times the rate of death than whites and other/unknown race/ethnicity had a 0.5 (0.3, 0.9) times the rate of death than whites. Men had almost

three times the rate of death compared to women. All Hazard Ratio estimates were significant at less than 0.05. Likelihood Ratio Tests Chi-squares were significant.

DISCUSSION

We sought to determine the relative survival of an unsheltered cohort from Boston, MA, during the decade from 2000 through 2009, using age-stratified Kaplan-Meier Survival Estimate curves, age-stratified Log-Rank Tests for Equality, and Cox Proportional Hazard Models. The overall probabilities of survival within the cohort at five and 10 years were low; on any given day the likelihood of an individual in the cohort dying was high. Whites, men, and middle and old age groups had the lowest probability of survival (or highest mortality). All Log-Rank Tests conducted were significant indicating at least one curve on each graph differed from the others. The Cox models revealed similar results. The older age groups had higher rates of death compared to the young age group. Blacks and other/unknown race/ethnicity had about half the rate of death when compared to whites. Men had nearly three times the rate of death than women.

Similar to other studies of mortality and homelessness, we found both a higher proportion of death and a higher rate of death among whites and men in our study.³⁰⁻³⁵ In the U.S., mortality rates among non-whites, although higher than whites, have been on the decline.⁵² Additionally there has been an increase in all-cause mortality for middle age whites which has been shown to be largely driven by drug OD, medical conditions related to alcohol, and suicide.⁵² Both factors have resulted in a narrowing of the gap for mortality between racial/ethnic groups in the U.S.⁵² Also, men in the U.S. have higher mortality rates than women, but for middle age men and women (i.e. 44-54 years old) patterns of death for both genders have been shown to be similar.⁵²

The reasons for the higher proportion of deaths and the higher mortality rate consistently observed among whites in homeless mortality literature are unknown. Geography may be a factor, as the demographics of homeless populations vary from region to region or from urban to rural settings. Within the same urban area, the location of available shelters or safety net system can be in areas that are

sometimes segregated. Donley and Wright 2012 found that the local shelter in the East Orange County, FL was in area that was historically black and more black homeless people used the shelter system than white homeless people.²² Safety concerns and not racism were given when the unsheltered group in the study, who were primarily white, were asked why they slept outside and did not utilize the shelter.²² Other researchers have concluded that the racial/ethnic findings in homeless mortality studies may be due to the causes of homelessness.³⁰ Some have surmised that more often population- and community-level causes such as poverty and discrimination are the causes homelessness versus individual-level factors such as substance use disorder or mental illness.³⁰ The few studies on mortality among homeless populations have been done primarily in urban settings, such as Boston, Philadelphia, and San Francisco, and may not reflect homeless populations in other parts of the country. A national or multi-location homeless mortality study that includes variables at different levels is needed to explore whether the disparity in death outcomes for white homeless persons is generalized across the country or specific to a few regions.

The period of time studied may also be a factor. For example, Baggett et al. 2013 found the leading cause of death for the general homeless population in Boston to be OD, and those deaths were primarily among white men. The Baggett et al. 2013 study was conducted from 2003 through 2008, a period that coincides with the emergence of the opioid epidemic in the U.S.³⁰ In MA, deaths from opioids have disproportionately affected whites and men.^{57, 65} Since 2005, over 80% of deaths from OD across the Commonwealth have been among whites.^{57, 65} Thus the finding of such health disparities among homeless white men may be influenced by the common causes of death during that particular time period.

The racial/ethnic composition of the unsheltered cohort differs from the general homeless population, with more whites and more men seen among the unsheltered population.^{20, 25} A possible explanation may be the interplay between shelter rules and substance use. Active substance use disorders can be barriers to accessing shelters. In many cities, including Boston, homeless individuals are allowed to enter a shelter intoxicated or “high” but cannot actively drink or use drugs once inside. Many with severe addictions to alcohol or drugs will experience symptoms of withdrawal during the night and avoid shelters in order to have access to alcohol or drugs and prevent withdrawal. Some cities have a shelter

system that is primarily “dry,” in that they do not accept individuals who are inebriated with drugs or alcohol. In cities with dry shelters, the majority staying on the streets are those with substance use disorders, no matter the severity, further delineating the unsheltered from the sheltered population. Likewise the severity of a substance use disorder can be a barrier to participation in medical and behavioral health care, as attending to the immediate needs of an addiction overwhelms other priorities such as health care. A higher prevalence of substance use disorders in street populations may contribute to the differences in all-cause and cause-specific mortality rates and survival analysis between the unsheltered and the sheltered homeless populations.

The reasons for the disparities in mortality among homeless whites and men are likely complex and multi-factorial, and these theories do not completely account for the outcomes in this study and in previous studies. Further research is warranted.

Strengths and Limitations

This study was a unique contribution to the literature on unsheltered individuals. To date it is the first study to examine the relative survival for an unsheltered cohort, and this study adds to our understanding of how the unsheltered population differs from the overall homeless population and may require specialized health care, supportive housing, and social services. The study design was prospective which helped to establish the temporality of sleeping outside and mortality. Cohort studies can be fraught with confounding. However, with the likelihood ratios testing, little to no change occurred in the Hazard Ratio estimates, which indicated little to no confounding in the models due to age or race/ethnicity.

While cohort studies can be subject to attrition, members of the cohort left the study when they died or when the study ended. The effects of attrition were decreased by linking the BHCHP data to the MDPH death occurrence files to optimize the ability to capture all the deaths that occurred in MA. Information from two limited NDI reports were added to the dataset. However, it was possible that some individuals in the cohort who were considered alive at the end of the study traveled to and died in other states. The effects of attrition could be further minimized by sending for an NDI report for those considered still alive at the end of the study.

It was also possible that there were unsheltered adults not encountered by the Street Team and thus not included in the study. While this number was likely to be low given Boston's small geographic size and the City's network of outreach services, such excluded individuals could have been different from the people included and could have been healthier and not in need of BHCHP's services or could have been more paranoid and refused care when it was offered. Exclusion of an unsheltered person was minimized by taking time to build a rapport with each individual. Another potential limitation was the group of 123 individuals without enough identifiable information to be included in the analysis may have differed from the 445 who met the eligibility criteria. Less information may have been available for this group because they were transient or not homeless long enough to build rapport with the Street Team to give their full names and other identifiers. This group could have had a higher burden of severe mental health issues and substance use disorders and thus were reluctant to offer accurate identifying information; this was mitigated by not seeking signatures for consent. Some of the group of 123 not included in the analysis could have been duplicates of those included in the cohort; meaning the record without sufficient identifiers was not changed or deleted in the database once the full name and date of birth or social security number for the person became known. In maintaining the database used for this study, all attempts were made to confirm the identifiers for the individuals included in the analysis by comparing the Access database records to that in the BHCHP EMR to conform name spelling, date of birth, and social security.

The demographics for the unsheltered cohort in our study were consistent with findings in other studies on unsheltered adults in the U.S. and in the Annual Homeless Assessment Report (AHAR) from 2015. The findings in our study were for an unsheltered cohort from a mid-sized city in the U.S. with shelter rules and regulations that may differ from those in other U.S. regions. As such, the results are likely to be generalizable to another unsheltered cohort in similar sized city in the U.S. but may not be generalizable if the area shelter rules and regulations differ significantly. In the 1980s the City of Boston guaranteed every person entry to a shelter if they choose.¹⁶⁻¹⁸ Since guaranteeing entry to a shelter on any given night is not uniform across the U.S., there could be differences in the unsheltered population from

cities with limited availability of shelter beds. However all would be subject to the same exposure of sleeping outside. Another aspect that could have affected the generalizability was access to health insurance and health care which has not been uniformly available across the U.S. MA residents have and have had access to near universal health insurance had such and other areas in the U.S. may not have access.⁴⁴ Everyone included in the study had direct access to continuous integrated medical and behavioral health care. These results then may be conservative compared to areas without adequate access to care.

Future Research

Future research is necessary to further investigate the disparities in mortality among whites and among men in our study and in other homeless mortality studies. Although this finding is similar to findings in the U.S., the causes for the homeless population may be different than for the U.S. as a whole. Studies that include multiple locations throughout the country are needed to understand the variations in not only in demographics and health status for the unsheltered population, but also in mortality outcomes. Rural and urban settings are likely to differ, and such studies will need to account for the difference in access to shelters and the approach to sheltering those with substance use disorders as well as the access to health insurance. Such research would broaden the generalizability of the findings and the results would help inform clinicians, policy makers, and public health workers about the social determinants for the unsheltered population, such as effects of shelter regulations for those who seek access and history of substance use disorder treatment, and what is needed beyond a medical and behavioral service delivery model of care to change outcomes for people sleeping rough in the U.S.

CONCLUSION

Whites, men and older age groups had lower probabilities of survival and higher rates of mortality than other groups in the study. Perceptions hold that minorities and non-whites are more vulnerable to disparities.⁶⁶ However this paper showed that whites and men have worse or worsening outcomes than non-white and minority counterparts, concurring with previous mortality research.^{30-33, 35}

Clinicians, policy makers, and public health officials need to be inclusive of all groups when creating interventions and programs to decrease marked mortality outcomes.

The results were seen despite near-universal insurance in MA during the study timeframe and access to a patient-centered integrated medical and behavioral health service delivery model of care focused on meeting the unsheltered population where they lived on the streets.⁴⁴ Future research should not only investigate new models of health care, but also the social determinants for the unsheltered population, such as harm-reduction programs and interventions in the shelter system and availability of substance use disorder treatment facilities. Research should also investigate types of housing and social services that are necessary to help change the marked mortality outcomes for this vulnerable sub-population of the homeless population and inform future social policy and interventions.

TABLES and FIGURES

Table 2-1: Characteristics of the Unsheltered Cohort from 2000-2009

	Cohort N = 445	Men N = 322	Women N = 123	Decedents N = 134	Boston 2000 Census ≥18 years old N = 472,582 ^a	MA ^b 2000 Census ≥18 years old N = 4,849,033 ^c
Characteristic	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Age (years)						
18-44	248 (55.7)	165 (51.2)	83 (67.5)	56 (41.8)	306,658 (64.9)	2,569,111 (53.0)
45-64	176 (39.6)	140 (43.5)	36 (29.3)	65 (48.5)	104,588 (22.1)	1,419,760 (29.3)
≥65	21 (4.7)	17 (5.3)	4 (3.3)	13 (9.7)	61,336 (13.0)	860,162 (17.7)
Race/Ethnicity						
White	299 (67.2)	223 (69.3)	76 (61.8)	108 (80.6)	283,109 (59.9)	4,180,644 (86.1)
Black	94 (21.1)	62 (19.3)	32 (26.0)	15 (11.2)	102,491 (21.7)	236,027 (4.9)
^d Other/Unknown	52 (11.7)	37 (11.5)	15 (12.2)	11 (8.2)	86,982 (18.4)	432,362 (8.9)
Gender^e						
Men	322 (72.4)			116 (86.6)	224,078 (47.4)	2,289,671 (47.2)
Women	123 (27.6)			18 (13.4)	248,504 (52.6)	2,559,362 (52.8)

^a Number reflects data on individuals ≥18 years old from Boston for the year 2000 from US Census Bureau: <http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml>

^b MA refers to Massachusetts

^c Number reflects data on individuals ≥18 years old from Massachusetts for the year 2000 from US Census Bureau:

<http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml>

^d Other Race/Ethnicity category contains individuals who reported their race/ethnicity to be American Indian, Hispanic, Asian, or race/ethnicity was unknown

^e No missing data for Gender

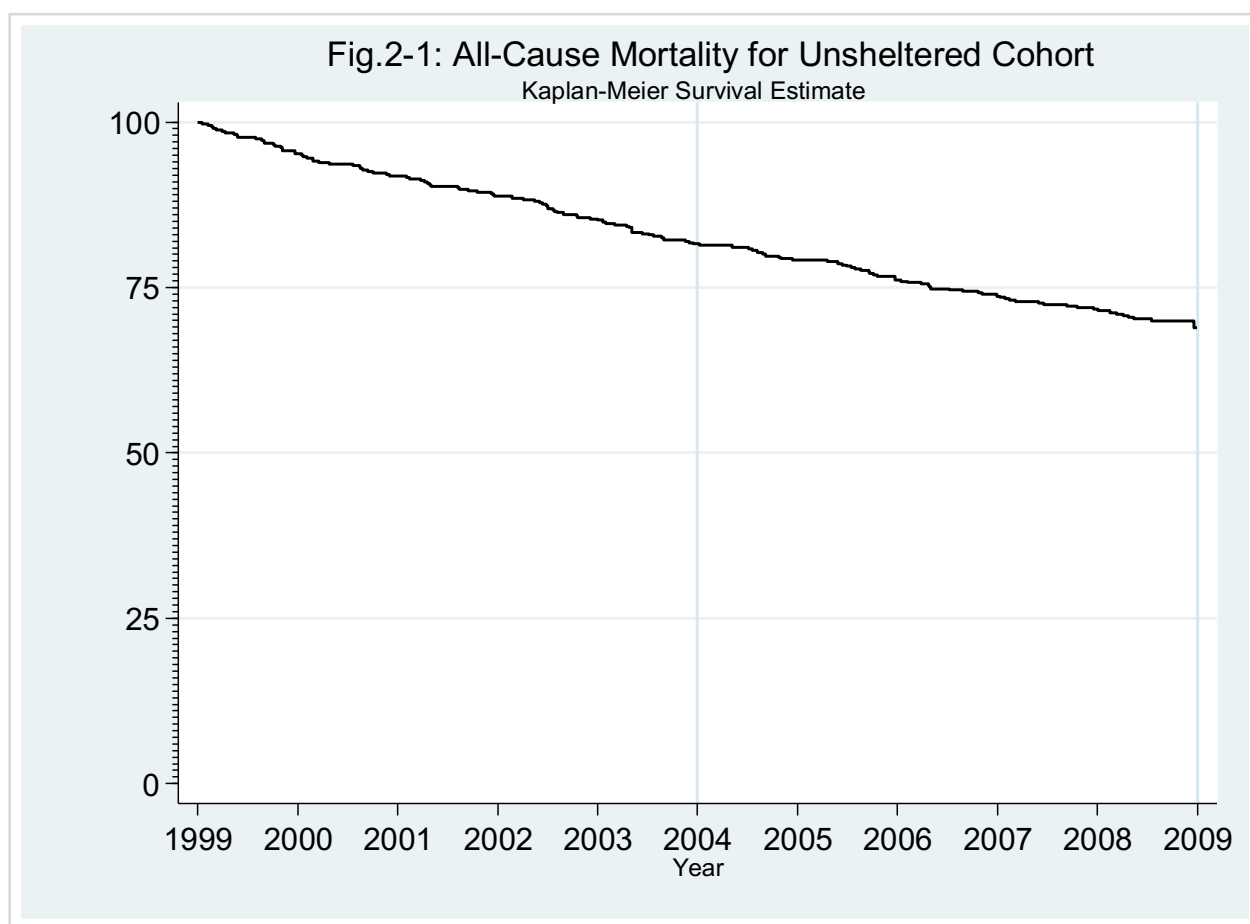


Fig.2-2: All-Cause Mortality for Unsheltered Cohort by Age

Kaplan-Meier Survival Estimates

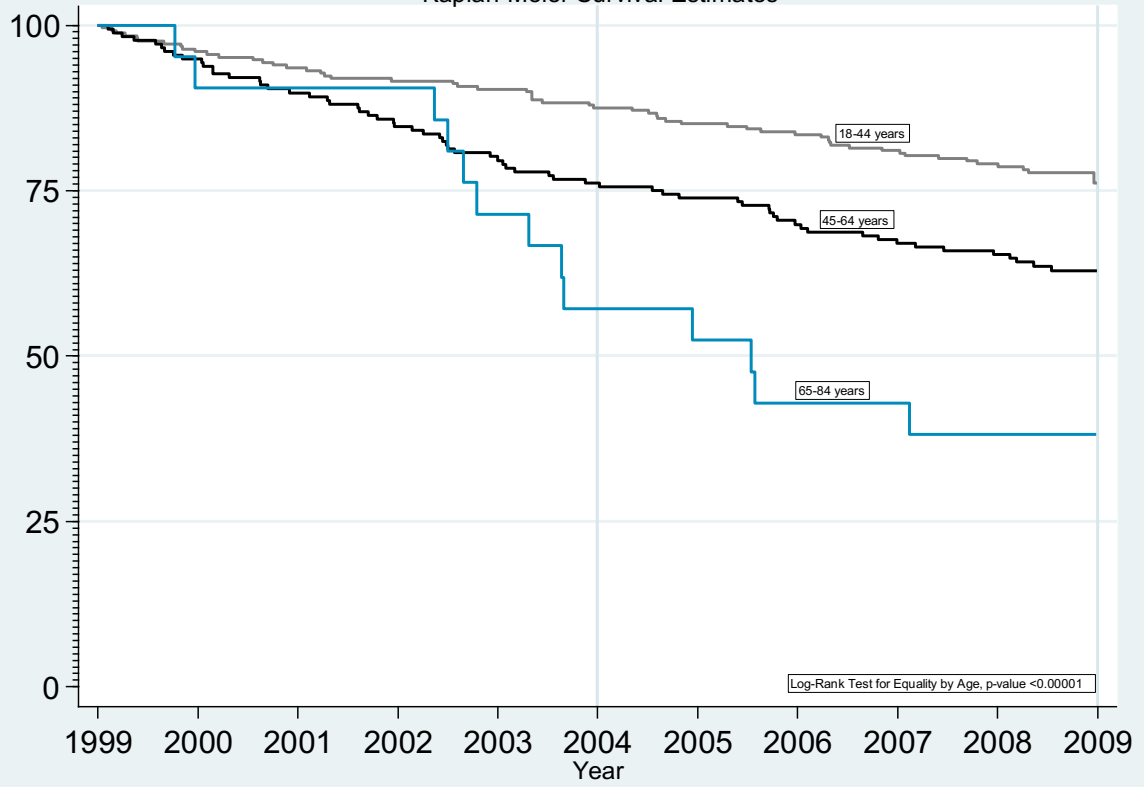


Fig.2-3: All-Cause Mortality for Unsheltered Cohort by Age and Gender
Kaplan-Meier Survival Estimates

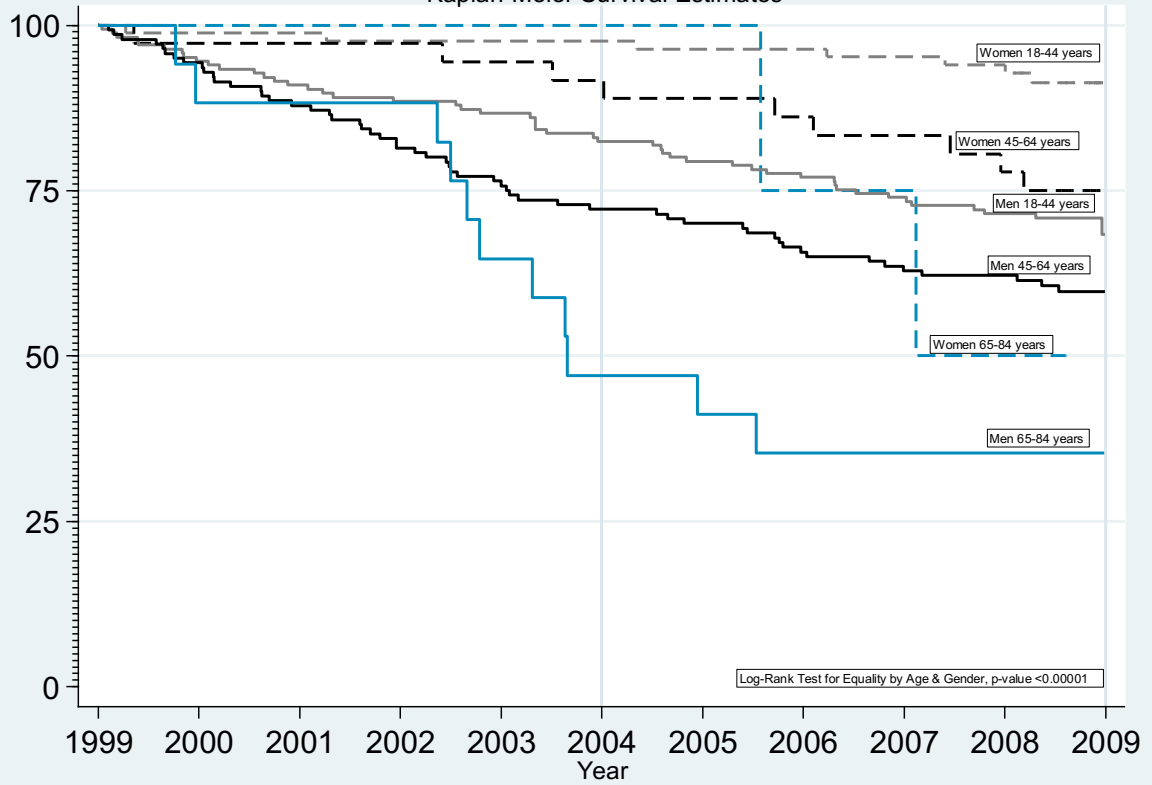


Fig.2-4: All-Cause Mortality for Unsheltered Cohort by Age and Race/Ethnicity
Kaplan-Meier Survival Estimates

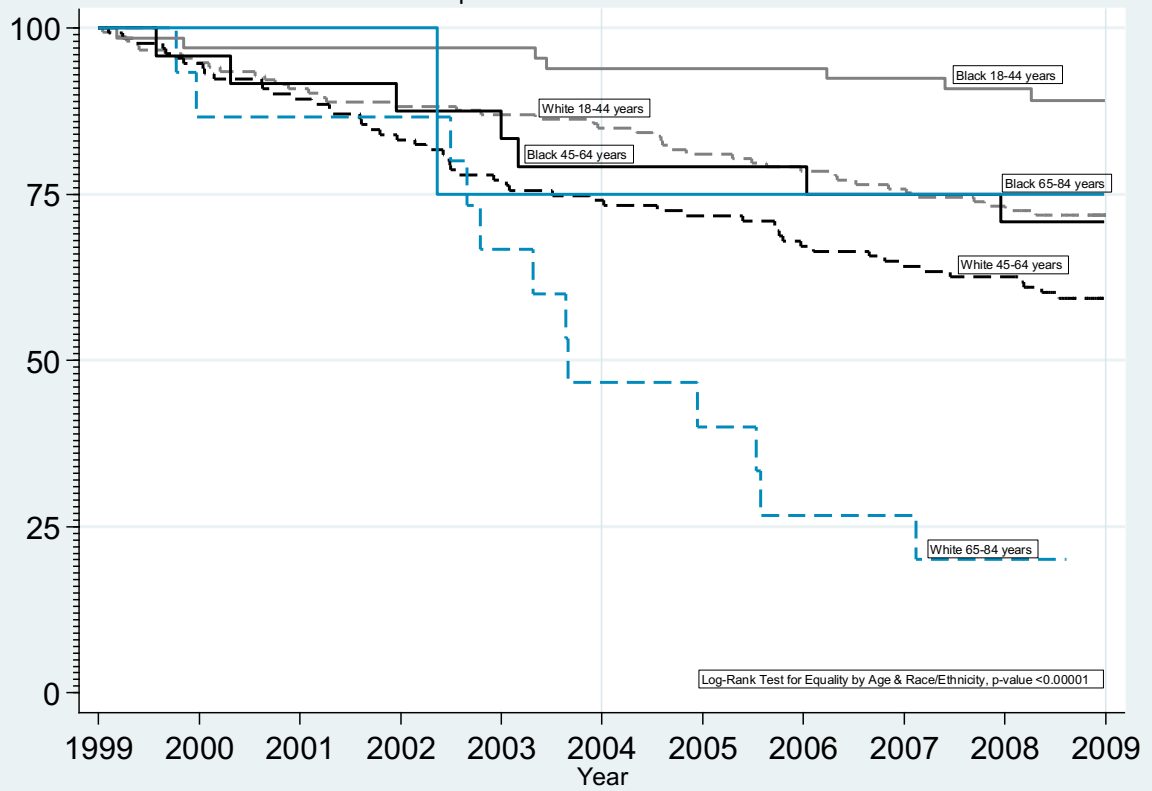


Table 2-2: Cox Proportional Hazard Model for Unsheltered Cohort from 2000-2009			
Model One (Age, Gender, Race/Ethnicity)			
	Hazard Ratio (95% CI) ^a	p-value (0.05)	Global Test p-value (0.05)
Age (years)			0.0005
18-44	1.0		
45-64	1.5 (1.01, 2.2)	0.019	
65-84	3.5 (1.9, 6.4)	<0.0001	
Race/Ethnicity			0.0007
White	1.0		
Black	0.4 (0.3, 0.7)	0.002	
^b Other/Unknown	0.5 (0.3, 0.9)	0.039	
Gender ^c			
Women	1.0		
Men	2.7 (1.6, 4.5)	<0.0001	

^a CI refers to Confidence Interval

^b Other Race/Ethnicity category contains individuals who reported their race/ethnicity to be American Indian, Hispanic, Asian, or race/ethnicity was unknown

^c No missing data for Gender

PAPER THREE

High-Risk for Mortality Criteria and Rough Sleepers: 10-year prospective study of high-risk and non-high-risk unsheltered adults from Boston, MA 2000 through 2009

ABSTRACT

Purpose: We described criteria to predict mortality developed at the Boston Health Care for the Homeless Program that was applied to an unsheltered cohort which divided the cohort into a high-risk group and non-high-risk group. Mortality for the two risk-level groups was then examined to determine if the high-risk group had a higher rate of mortality than the non-high-risk group.

Methods: Using a 10-year prospective cohort study design, we conducted survival analysis for the high-risk and the non-high-risk groups within the unsheltered cohort. Age-standardized all-cause and cause-specific mortality rates and age-stratified rate ratios for the high-risk and non-high-risk groups were calculated using two comparison groups: a general homeless cohort from Boston, MA from 2003 through 2008 and the population of Massachusetts from 2000 through 2009.

Results: The unsheltered cohort of 445 was divided into two groups by applying the high-risk for mortality criteria for mortality; 119 high-risk and 326 non-high-risk. During the study 52 high-risk group deaths occurred and 82 non-high-risk group deaths. The high-risk group had a higher proportion of whites and lower proportion of blacks and higher average age. Age-stratified Kaplan-Meier Survival Estimate curves for the high-risk group had lower probabilities of survival. Whites, men, older age, and the high-risk group had higher rates of death. All-cause age-standardized mortality ratios were higher for the high-risk group than the non-high-risk group; both groups had higher mortality rates for comparisons to Massachusetts and for most comparisons to the general homeless cohort. In both risk groups, cause-specific mortality rates were highest for noncommunicable diseases and diseases related to substance use.

Conclusions: The high-risk for mortality criteria predicted an increased mortality rate and lower probability of survival for the high-risk group in the unsheltered cohort. Despite an increased rate for mortality and lower relative survival among the high-risk group, nearly all outcomes for the non-high-risk group were higher than both comparison groups. The high-risk and non-high-risk groups from an unsheltered homeless cohort had marked mortality rates and premature mortality. Creative efforts are needed to bring health, housing, and supportive services to both the high-risk and non-high-risk groups of the unsheltered homeless population.

INTRODUCTION

Previous studies on homelessness and mortality have shown marked mortality rates and premature mortality. One such study conducted by Dr. Stephen Hwang and colleagues at the Boston Health Care for the Homeless Program (BHCHP) and Harvard T.H. Chan School of Public Health (Harvard Chan School; formerly known as Harvard School of Public Health) analyzed a cohort of 17,292 homeless individuals seen by BHCHP from 1988 through 1993.³⁵ High all-cause and cause-specific mortality rates were found for the homeless cohort when compared to the general population of Boston.³⁵ In a subsequent study using the same cohort, Hwang et al. 1998 looked for risk factors for mortality for the general homeless population.³⁴ They found a high risk of death from substance use related disorders and conditions for the homeless population.³⁴ More notable was that they found homeless adults with HIV/AIDS, renal disease, liver disease, and arrhythmia had an extremely high risk of death and that these diseases and conditions conferred an even greater risk of death than substance use disorders alone.³⁴

Hwang et al. 1997 and 1998 studies were seminal works for the clinicians and researchers at BHCHP, especially for those working directly with the unsheltered street population in Boston. They used the results of these studies as well as clinical evidence and unpublished data on street deaths to develop the “high-risk for mortality criteria.” The criteria was developed for two reasons: (1) to help identify those who might be at the highest risk for dying on the streets and (2) to use as a tool to help develop a prospective study on the unsheltered population in Boston. The criteria were not envisioned to be used for allocating scarce resources or to preferentially offer treatment to the high-risk (HR) group and not the non-high-risk (NHR) group, but rather to heighten the awareness and clinical concern when serving those sleeping on the street. The research project was envisioned to collect data through clinical encounters with patients on the streets and medical chart review, not by self-report, on a relatively unknown group of men and women. This data collection became the basis for this paper as well as our previous studies on the unsheltered population in Boston, MA.

Two key studies influenced the current federal policy on homelessness and intersected with BHCHP’s evolving work with the unsheltered population. The first, by Kuhn et al. 1998, used cluster

analysis on shelter admissions in New York City (NYC) from 1988 to 1995 and Philadelphia from 1991 to 1995 and found a distinct typology: (1) 80% were transiently homeless, they had a single brief stay and did not return to the emergency shelter system, (2) 10% were episodically homeless, they used the shelter system repeatedly for extended periods of time, and (3) 10% were chronically homeless, they slept every night in the shelters.⁷ This latter group of chronically homeless persons had the highest burden of co-occurring medical, mental health, and substance use problems, consumed half of the total shelter time, and rarely met the requirements for available housing.⁷

A second study by Tsemberis et al. 2000 described a successful method of housing people with serious mental illness and addictions directly from the streets using a modified assertive community treatment (ACT) model; this method which Tsemberis and his team spearheaded was nicknamed “housing first.”⁶⁷ Housing first truncated the traditional linear route to housing, which required several steps, such as taking psychiatric medications or achieving long periods of sobriety through detoxification and recovery programs, in order to be housing ready.⁶⁷ For many chronically homeless people, particularly those on the streets, these requirements were often insurmountable. In 2003, the United States (U.S.) Department of Housing and Urban Development (HUD) officially defined chronic homelessness and updated the definition in 2015; shortly after 2003 Federal funding for housing initiatives adopted the housing first model as a key tool in a nationwide effort to end chronic homelessness.^{8, 10}

Employing the housing first model in many areas was impeded by scarce housing resources available. Community Solutions, formerly Common Ground, a non-profit housing and human service agency in NYC, used a housing first approach to house individuals living on the streets of Times Square and mid-Manhattan in the early 2000s.⁶⁸ To prioritize the most vulnerable persons on the streets for the limited housing available, Community Solutions developed the Vulnerability Index (VI), using the high-risk for mortality criteria from BHCHP.⁶⁹ The VI was a self-report survey with a scoring rubric, with those with the highest scores receiving the highest priority for housing.⁷⁰ Community Solutions subsequently partnered with HUD to initiate a four-year 100,000 Homes campaign from 2010 through 2014.⁶⁸ During that time 105,580 homeless people were recorded as housed in 186 communities across

the U.S.⁶⁸ Most of these communities utilized the VI as a tool to prioritize those most in need of housing.^{68, 69} Others adapted the tool or used alternative assessment tools to meet specific community needs with encouragement from Community Solutions.^{68, 69} The use of the VI was like a contagion passed from community to community.

The VI was not designed to take the place of the high-risk for mortality criteria developed at BHHCP nor was it the basis of a research project. The VI was a highly effective community-organizing tool that brought together politicians, policy-makers, business leaders, homeless services leaders and homeless people catalyzed in the interest of ending street homelessness, and its usage helped place many homeless persons in supportive housing. The VI has not, and to date has never, been a validated measure.

Other tools for prioritizing individuals for housing were and are utilized as well: the Vulnerability Assessment Tool (VAT) and the Vulnerability Index-Service Prioritization Decision Assistance Tool (VI-SPDAT).⁷¹⁻⁷⁴ Some confusion has been the nomenclature, as the VI was designed to assess risk for mortality while others focused on function rather than mortality as an indication of vulnerability.⁷³ Hobson and colleagues at the Downtown Emergency Services Center in Seattle, WA, developed the VAT, a questionnaire that evaluates an individual's level of functioning across 10 domains that has been tested for reliability and validity.⁷³ The VAT originally did not assess risk of mortality, although medical constructs were added to the tool in 2009.⁷³ Community Solutions, working with OrgCode Consulting, Inc. in 2013, combined the VI with the SPDAT to create the VI-SPDAT that is now a HUD approved tool for prioritizing housing for chronically homeless persons.^{71, 72, 74}

The purpose of this paper was not to validate the VI or any of the other assessment tools used to prioritize chronically homeless individuals for housing, but rather to determine if meeting the high-risk for mortality criteria increased the rate of mortality for an unsheltered cohort from Boston. It is also the first such paper to describe and apply the high-risk for mortality criteria. In this paper, first we described the high-risk for mortality criteria. Second, survival analysis was conducted for the HR and NHR groups. Third, age-standardized all-cause and age-standardized cause-specific mortality rates were calculated using two comparison groups: (1) the population of Massachusetts (MA) from 2000 through 2009 and (2)

a general homeless cohort from Boston from 2003 through 2008. Our hypotheses were threefold: (1) all-cause and cause-specific mortality rates will be higher for the HR group than the NHR group, the general homeless cohort, or the MA populations; (2) relative survival will reveal lower probabilities of survival and higher rates of death for the HR group than the NHR group; and (3) based on previous research, whites and men will have disproportionately higher mortality rates than groups.

METHODS

Study Design and Study Population

We conducted a 10-year prospective study from January 1, 2000 through December 31, 2009. The study population consisted of unsheltered homeless individuals sleeping on the streets of Boston who were patients of BHCHP Street Team. Eligibility criteria were: (1) homeless individuals who were 18 years old or older; (2) sleeping unsheltered on the streets of Boston for one night or more during the calendar year 2000; (3) had at least one face-to-face encounter with a BHCHP Street Team clinician during the calendar year 2000; and (4) were included in the BHCHP Street Team Microsoft® Office Access (Access) database with a first and last name and either a date of birth or a social security number which were necessary for linking data. The database had 568 records. Using the above inclusion criteria 445 unique unsheltered individuals were identified for the cohort. Exclusion criteria were based on lack of identifiable information and age. One hundred and twenty three records with only a first and last name or only a first name were excluded from the analysis. The remaining 445 records were linked and matched to the BHCHP electronic medical record (EMR) to confirm first and last name spellings, date of birth, social security number, gender, and race/ethnicity. Later the 445 records were linked and matched to the Commonwealth of Massachusetts Department of Public Health (MDPH) death occurrence files to confirm deaths. There were no known duplicates in the cohort and no one was added after December 31, 2000. Everyone in the cohort was alive at the time of enrollment. All cohort members were followed prospectively from their enrollment date until either their date of death or the end of the study on December, 31, 2009. All data for the cohort were collected prospectively and stored in an Access

database starting on January 1, 2000, and continuing through December 31, 2009. The study met Boston University Medical Center Institutional Review Board approval and was assigned study number H-22365, with an Authorization Agreement from Harvard Chan School with assigned study number 16-0357.

Study Context and Setting

The study was conducted at BHCHP with data analyzed at Harvard Chan School. Researchers were from BHCHP, Harvard Chan School, and the University of Toronto. BHCHP is the country's largest and most comprehensive freestanding Health Care for the Homeless program.^{36,37} The city-wide program was initiated in 1985 and conceived to serve as a catalyst within the mainstream of Boston's hospitals and community health centers, enticing clinicians to venture from traditional clinics and offer direct care in places familiar to homeless persons.^{36,37} Health care is delivered through a network of accessible clinics at two teaching hospitals, Massachusetts General Hospital and Boston Medical Center, at over 60 shelters and soup kitchens, on the streets, and in permanent supportive housing.^{36,37} Multidisciplinary teams of internists, nurse practitioners, physician assistants, psychiatrists, social workers, nurses, and case workers provide integrated medical, behavioral, and oral health care.^{36,37} Each year the number of unduplicated patients seen has steadily increased from 1,246 in 1985 to 11,097 in 2015.^{36,37} BHCHP also operates a 24-hour 104-bed medical respite program that provides acute and sub-acute, pre- and post-operative, recuperative and rehabilitative, and palliative and end-of-life care.^{36,37} The respite program, Barbara McInnis House, had over 2,400 admissions for more than 1,200 unduplicated persons in 2015 who would have otherwise required acute care hospitalizations.^{36,37}

After founding BHCHP, clinicians and researchers realized that individuals living on the streets and avoiding shelters were not served adequately by either the mainstream medical system or the early BHCHP service delivery model of interconnected clinics in two major teaching hospitals and over 20 adult and family shelters.³⁸ In response to a number of deaths on the streets during 1985-1986, the MDPH contracted with Pine Street Inn (PSI), New England's largest adult homeless shelter, to establish an overnight mobile van.³⁸ Rather than a medical van, the community requested a nightly service that brought food, blankets, and clothing to those sleeping outside. A BHCHP physician rode on the van two

nights each week, becoming familiar with the city's unsheltered population and laying the groundwork for the BHCHP Street Team. Today clinicians from BHCHP's Street Team continue to join the PSI van two nights each week, while the Street Team has grown to include internists, psychiatrists, nurse practitioners and physician assistants, and case workers. Integrated and co-located medical and behavioral health care is offered directly on the night van as well as on the streets during daytime hours to over 500 unduplicated rough sleepers each year. This experience provided the foundation for this study initiated on January 1, 2000.

Data Collection

BHCHP Data

Face-to-face encounters consisted of a Street Team clinician meeting with an unsheltered individual directly on the street during a daytime or nighttime session for medical, behavioral health, or case management care. Street Team clinicians documented the face-to-face encounters on paper while on the street and later the notes were transcribed by a research assistant into the Access database. Data collected at the initial visit and over time were first name, last name, encounter date, encounter and sleeping location, date of birth, social security number, race/ethnicity, gender, medical and behavioral health diagnoses, and clinician name. As new information became known, such as a last name or date of birth, the Access database was updated. As well, date of death and cause of death were added to the database when a death was known to have occurred or by matching the record to the MDPH death occurrence files or to a National Death Index (NDI) report. At the end of the study, only two variables, social security number and race/ethnicity, had missing data. Fifteen records, or 3.4%, had a missing social security number and seven records, or 1.6%, had an unknown race/ethnicity. For the study, the racial and ethnic categories were defined as: white, black, and other/unknown which contained individuals who identified as American Indian, Hispanic, Asian, or if race/ethnicity was unknown. There were three age categories: 18-44 years old, 45-64 years old, and 65-84 years old. Gender was a dichotomous variable (man or woman), without any unknowns. A dichotomous risk-level variable for the high-risk for mortality criteria was created for this study (HR or NHR); the creation of which was informed by previous

homeless mortality research conducted at BHCHP and medical chart reviews of unsheltered adults deaths.^{34, 35, 38}

The records in the Access database were designated as HR upon enrollment if an individual in the study had been sleeping on the streets for six consecutive months or more plus had any one or more of the following seven criteria: (1) suffered from tri-morbidity (i.e. medical illness co-occurring with mental illness and active substance use disorder); (2) one or more hospital admissions or BHCHP respite admissions anytime during the previous year; (3) three or more visits to the emergency department (ED) in previous three months; (4) 60 years old or older; (5) diagnosis of HIV or AIDS; (6) diagnosis of cirrhosis, end stage liver disease, or renal failure; and/or (7) history of frostbite, hypothermia, or immersion foot. The information needed to determine if an unsheltered cohort member was either HR or NHR was obtained after the first date of contact during the year 2000 by chart review of the medical records in the BHCHP, MGH, and BMC systems as well as what had been previously gathered in the Access database records by the research assistant and the clinicians involved in the study. If the person met the criteria the record was designated HR and if the person did not meet the criteria, the record was categorized as NHR. There were no missing data for the risk-level variable. The designation of HR or NHR only occurred at enrollment and was not reviewed over the course of the study.

Box 3-1: High-Risk for Mortality Criteria

≥18 years old and sleeping rough for ≥6 consecutive months, PLUS ≥1 of following 7 criteria:

- 1) Tri-morbidity (multiple medical illnesses co-occurring with mental illness and active substance use disorder);
- 2) ≥1 hospital admission or BHCHP respite admission anytime during previous year due to major medical problem(s);
- 3) ≥3 visits to the ED in previous 3 months;
- 4) ≥60 years old;
- 5) HIV or AIDS;
- 6) Cirrhosis, end stage liver disease, or renal failure; and/or
- 7) Previous history of frostbite, hypothermia, or immersion foot

Decedent Data

The primary source for decedent data were the MDPH death occurrences files for the calendar years 2000 through 2009 which was used to confirm the known deaths in the BHCHP Access database as

well as to add additional deaths if previously unknown. Only the variables of interest for the study were analyzed from the MDPH data. These were: first name, last name, middle name, maiden name, date of birth, social security number, gender, race and ethnicity, date of death, underlying cause of death and second through the sixteenth multiple causes of death, all in International Classification of Diseases, Tenth Edition (ICD-10) code format. The other death data were limited reports from the NDI. Over the course of the study, two reports were requested from the NDI on a portion of the cohort for whom whereabouts was unknown at the time. Data extracted from the NDI reports were: underlying cause of death and multiple causes of death also in ICD-10 format, date of death, and state of death.

Cause of Death Definitions and Code Groupings

The underlying causes of death and multiple causes of death data from MDPH and NDI were previously processed by the National Center for Health Statistics (NCHS) using well-established computer algorithms employed to select the underlying cause of death from the list of conditions reported on death certificates.³⁹ The underlying cause of death ICD-10 codes that were used to analyze causes of death and the groupings used were based on previous literature, the Centers for Disease Control and Prevention (CDC) Wide-ranging Online Data for Epidemiologic Research (WONDER) and were previously described by Roncarati et al. 2016.^{30, 35, 40, 41, 64} A list of and definitions for the ICD-10 groupings used in the study can be found in a supplemental table.

Matching Data

Link Plus, version 2.0, a probabilistic record linkage program developed at CDC, Division of Cancer Prevention and Control in support of CDC's National Program of Cancer Registries (NPCR), was used to match the BHCHP data to the MDPH death occurrence data. Each match was manually reviewed. A record was accepted as the same record if they matched on one or more of the following: (1) matching social security number, (2) matching first and last name, and month and year of birth, plus or minus one year, or (3) matching first and last name, month and day of birth.^{30, 35, 39} This algorithm was similar to that used at the NDI to match records and has also been reliably used by previous researchers studying mortality in homelessness populations.^{30, 35, 39} Using the above algorithm, 122 matches from the BHCHP

data and the MDPH data were confirmed. An additional 12 records were manually matched from the two limited NDI reports; these 12 deaths occurred outside of MA. The total number of deaths for the cohort was 134.

Statistical Analysis and Study Measures

Descriptive analysis consisted of tabulating the overall cohort, risk-level, decedents, as well as the 2000 census of Boston and MA by age category, race/ethnicity category, and gender. All statistical analyses were performed using Stata[®]14 (StataCorp, College Station, TX) and Microsoft[®] Office Excel 2013. Crude mortality rates for all-cause and cause-specific mortality were calculated using number of deaths in each category divided by person-years of observation for that category to create incident rates. Strata specific incident rate ratios were calculated by taking one crude mortality rate within a stratum and dividing it by another crude mortality rate within a stratum. Age-standardized all-cause and cause-specific mortality rates were calculated using indirect standardization, to create age-standardized mortality ratios (SMR). The HR group and the NHR group were used separately as standard populations and were compared separately to two populations: (1) mortality data for MA population from 2000 through 2009 and from CDC WONDER underlying causes of death and (2) a general homeless cohort from Boston from 2003 through 2008 used by Baggett et al. 2013 in “Mortality Among Homeless Adults in Boston: Shifts in Causes of Death Over a 15-Year Period.”^{30, 42}

The SMRs were calculated by: (1) creating age-specific per person-year mortality rates for the young, middle, and old age categories for MA and the general homeless cohort; (2) multiplying the age-specific per person-year mortality rates by age-specific person-year for both the HR and NHR groups; (3) summing the three age-specific products separately for both the HR and NHR groups to determine the expected number of deaths for each group; and (4) dividing the number of observed deaths by the number of expected deaths separately for both the HR and NHR groups. SMRs were calculated when the number of deaths in a category was five or more. Ninety-five percent confidence intervals were calculated for crude mortality rates, rate ratios, and SMRs.

Survival analysis consisted of creating age-stratified Kaplan-Meier Survival Estimate curves by risk-level which were separated into three separate graphs, young, middle, and old age respectively. Age-stratified Log-Rank Tests for Equality by risk-level were completed. The variables of interest for survival analysis were age, risk-level, date of enrollment, and date of death. Time until death was modeled using three Cox Proportional Hazard Models. Model one contained all variables. Model two was run without age and model three was run without race/ethnicity. Significance of multi-category prediction (i.e. age and race/ethnicity) was assessed using a Likelihood Ratio Test. Women, whites, NHR, and young age category were used as reference groups. A significance level of less than 0.05 was used for all testing.

RESULTS

Cohort Characteristics

The unsheltered cohort included 445 unsheltered individuals, 119 were HR and 326 were NHR. There were 134 decedents: 52 from the HR group and 82 from the NHR group. The HR group had a higher proportion of whites and men, with a lower proportion of blacks and women, than the NHR group and the overall unsheltered cohort (Table 1). The average age for the HR group was 47 years old, with a range of 30 to 81 years old, and 43 years old for the NHR, with a range of 18 to 79 years old (data not shown). Comparing the HR to the census of Boston and MA for the year 2000, the proportion of middle age, whites, and men were all higher for the HR individuals.

Survival Analysis

Kaplan-Meier Survival Estimate Curves and Log-Rank Tests for Equality

All the Kaplan-Meier Survival Estimate curves for the HR group for the three age categories had lower probabilities of survival (or a higher mortality) at five and 10 years than the NHR group (Fig. 1-3). All age-stratified Log-Rank Tests for Equality for HR and NHR were statistically significant; at least one curve on the graph was significantly different from the other curves.

Cox Proportional Hazard Models with Likelihood Ratio Tests

Cox Proportional Hazard model one which included age, race/ethnicity, gender, and the HR variable, showed a Hazard Ratio for the HR group of 1.7 ((95% confidence interval (CI)) 1.2, 2.4) times greater than that of the NHR group (Table 2). Middle age and old age both had higher Hazard Ratios than young age. The Hazard Ratio for blacks was 0.5 (0.3, 0.8) times that of whites. Men had 2.7 (1.6, 4.4) times greater rate of death than women. The Hazard Ratio estimates and corresponding p-values changed slightly when age or race/ethnicity was removed from the model in models two and three (data not shown). The Chi-squared values for the Likelihood Ratio Tests were significant.

Mortality Rates

The total person-years for the cohort were 3608.7 with an average of 8.2 person-years and range of 0.1-9.9 person-years. The crude mortality rate for the cohort was 3713.2 (3110.9, 4397.5) deaths/100,000 person-years (Table 3). The rate ratio (RR) for HR compared to NHR was 2.0 (1.4, 2.8). The age-specific RR for young and middle age for the HR group were high when compared to the population of MA and the general homeless cohort. The overall SMR for the HR group was 15.5 (11.7, 20.2) times higher than population of MA and 4.0 (3.0, 5.2) times higher than the general homeless cohort (Table 5). SMRs for the NHR group were 7.9 (6.3, 9.8) times higher than the population of MA and 2.2 (1.8, 2.8) times higher than the general homeless cohort. The SMRs for HR men and NHR men were also high when compared to MA and a general homeless cohort.

Causes of Death

High-Risk Group

The SMRs for the HR group compared to the population of MA and to the general homeless cohort were high and significant and double or nearly double that of the NHR group (Table 5). The highest rates of death for the HR group when compared to both the population of MA and the general homeless cohort were noncommunicable diseases such as heart disease, HIV/AIDS, injuries, non-poisonings, and conditions directly attributable to substance use such as alcohol use and opioid use. The SMR for substance use category, (i.e. contained SUD, chronic liver disease, and drug overdose (OD) deaths), was high for the HR group when compared to both MA and the general homeless cohort.

Non-High-Risk Group

The comparisons for the NHR group to the population of MA were high and significant. Fewer SMRs for the NHR when compared to the general homeless cohort were above 1.0. Again the highest rates of death for the NHR, although the rates of death for the NHR were about half of the rate for the HR group, the highest rates again were seen for heart disease and cancer, injuries, non-poisonings, HIV/AIDS, and deaths directly related to substance use.

There were less than five deaths for both HR and NHR groups for several diseases to calculate a stable SMR. In the HR group there were too few deaths from OD to calculate an SMR and in the NHR group there were too few deaths from chronic liver disease to calculate an SMR. During the 10-year study there were no deaths from diabetes mellitus or tuberculosis and one death from hypothermia which was included in the injury non-poisoning category. The OD deaths occurred evenly throughout the study; no one year contributed to all the OD deaths nor did the deaths not occur during the latter half of the study.

DISCUSSION

This study builds upon our earlier studies that showed unsheltered homeless persons in Boston suffer from a greater rate of death than the general homeless population, and marked disparities in mortality outcomes when compared to the population of MA.^{64, 75} This study was designed to explore those differences using HR criteria from BHCHP. The purpose was: (1) to define the high-risk for mortality criteria developed by BHCHP, (2) to determine whether these criteria predicted an increased mortality for an unsheltered cohort, and (3) to conduct survival analysis. Kaplan-Meier survival estimate curves showed a lower probability of survival for the HR group compared to the NHR with statistically significant Log-Rank Tests of Equality. Controlling for gender, age, race/ethnicity, the Cox Proportional Hazard Model revealed that the HR group had two times rate of death that the NHR group. The all-cause mortality rates were high for both the HR and NHR groups. When compared to the population of MA, the HR group a 15 times higher rate of death than residents of MA and were four times more likely to die than the general homeless cohort. The NHR had about half the rate of death of the HR group when

compared to other populations. Nonetheless, the NHR still had marked disparities in mortality outcomes, with a rate of death almost eight times higher than Massachusetts residents and more than twice the rate of death of the general homeless cohort. The cause-specific mortality rates for both the HR and NHR were high for noncommunicable diseases, HIV/AIDS, injuries, non-poisonings, and substance abuse related causes. Insufficient OD deaths were observed in the HR group to calculate a mortality rate; similarly, insufficient deaths from chronic liver disease in the NHR group occurred to calculate a mortality rate. Overall, only one death was due to hypothermia, very few suicide or homicide deaths, and no deaths due to diabetes or tuberculosis occurred.

The relative survival and mortality outcomes in this study showed that the HR group from an unsheltered cohort had an increased rate of mortality when compared to the NHR group from the same cohort. Several factors could have affected this difference, including variation in age between the two groups. The youngest in the HR group was 30 years old and the youngest NHR individual was 18 years old. The proportion of middle age category in the HR group was higher than in the NHR group, yet the numbers of those 60 years old and older were about the same for both risk-levels. The age range for the old age category was similar between groups.

Another factor for the higher rate of death seen for the HR group could be criteria for HR itself. Age was one of the seven criteria. In order to be characterized as HR, a homeless person needed to be sleeping outside for six consecutive months or longer which for some might occur at an older age. Length of time homeless was not determined for the NHR group, and individuals in this group could have been sleeping outside for a single night in the year 2000 or for many years. As stated previously, the proportions of those 60 years old or older for both risk-levels were about the same. Additionally when age was accounted for in the Cox model, an almost double the rate of mortality was seen for the HR group compared to the NHR group.

More chronically homeless individuals may have been part of the HR group than the NHR group, and chronicity could be a risk for mortality. This has not been studied to date, but is critical to consider in future studies of homelessness and mortality. Those who are chronically homeless and unsheltered have

been shown to be sicker, have more substance use disorders, and are older.²⁵ Although the six consecutive months or longer time component in this study was not the same as HUD's requirement of time homeless to qualify as chronically homeless, most of those who met the HR criteria had been known by BHCHP Street Team for decades and had been known to be sleeping outside for many years consecutively. HUDs time requirement to consider an individual or family chronically homeless is: homeless for one consecutive year or on at least four separate occasions in the last three years.^{8,10} Alternatively, many of the NHR group were seen only once by the Street Team. Aside from age over 60 years, the other high-risk for mortality criteria suggest medical or psychiatric disability another necessary element of the chronically homeless HUD definition.^{8,10} By design, the HR cohort was likely homeless for longer periods of time and suffered from more severe medical and behavioral health problems than the NHR group. However, the goal of the HR criteria was to identify those living on the streets who have a greater risk for mortality, which was shown to be true from the outcomes of this study.

Similar causes of death from noncommunicable (NCD) and communicable disease, substance use, and injuries, non-poisonings were seen with both the HR and NHR groups, with the rate of dying from these causes about twice as high in the HR group. While the reasons for this difference were not clear from our study, we speculate that the high-risk for mortality criteria identified those whose conditions and disabilities were more advanced or present for longer periods of time.

Too few cases of OD occurred in the HR group and too few cases for chronic liver disease occurred in the NHR group to calculate an SMR. While the numbers were too small to reach conclusions about a fundamental difference in drugs of choice between the two risk-levels, several considerations may be relevant. On the surface there appeared to be higher alcohol use disorder in the HR group and higher opiate use in the NHR group. Most of the drug OD occurred in the young age categories in the setting of a younger NHR group. Seven of the OD deaths were from the young age category. The average age for an OD death was 38 years old and the range was 28-47 years old.

Over three-quarters (76.5%) of the HR group was white, a slightly higher proportion than the NHR group (63.8%). This difference may also be reflective of the chronicity of the HR group and that

those characterized as NHR were living unsheltered for a shorter time. Thus the true demographic of those sleeping outside chronically is a higher proportion of whites. Previous studies of unsheltered and sheltered homeless cohorts in Boston have shown have disproportionately higher rates of mortality and lower survival rates for whites.^{30, 34, 35, 64, 75} Additionally a recent study by Metraux et al. 2016 found that the majority of people who were homeless and unsheltered and who died in Philadelphia were white.⁷⁶

The high-risk for mortality criteria developed by BHCHP and utilized in this study were used in the development of the VI by Common Ground in NYC and the use of the VI as well as variations of the VI spread across the U.S. like a contagion in an effort to allocate scarce resources and house the most vulnerable homeless people. The purpose of this study was not to test the validity and reliability of the VI or any of its iterations, but rather to investigate whether BHCHP's high-risk for mortality criteria, gleaned from previous BHCHP mortality studies and clinical evidence, predicted a higher rate of mortality and lower probability for survival for individuals outside in Boston. While these high-risk for mortality criteria were related to the VI, the purpose and methodology are different. BHCHP's high-risk for mortality criteria have a dual purpose as: (1) a clinical tool to help clinicians better identify medical and behavioral health conditions that may place the unsheltered population at a higher rate for death and who may benefit from enhanced medical, behavioral health, and social services; and (2) to advance knowledge of this vulnerable unsheltered population by prospectively following a cohort, quantifying mortality outcomes and understanding relative survival for those characterized as HR or NHR. What was learned from applying the criteria to an unsheltered adult cohort in this study did confer information about vulnerability but not necessarily about a greater or lesser need for housing. In contrast, the VI was an effective community-organizing tool that catalyzed interest in unsheltered homeless persons as well as other sub-groups within the homeless population and resulted in thousands of people being placed in supportive housing in cities and counties throughout the U.S.

Strengths and Limitations

This third study on mortality for the unsheltered population in Boston adds to the growing literature on unsheltered homelessness. For the first time, high-risk for mortality criteria developed from

previous homelessness mortality research conducted at BHCHP and clinical evidence were applied to a cohort of unsheltered individuals living on the streets of Boston and relative survival and all-cause and cause-specific mortality rates were calculated for both HR and NHR groups and compared to both a general homeless cohort from Boston and the population of MA.

The prospective cohort study design was a strength of the study, as we were able to apply the HR criteria at enrollment, which allowed us to establish the both temporality of sleeping outside and which HR criteria were met by each individual before outcomes occurred. A potential limitation of the study is the unknown chronicity of homelessness for the cohort. While we were able to account for a minimum length of time sleeping on outside for those who met the HR criteria, this was not done for the NHR group and thus the effect of chronicity of homelessness on mortality was not addressed in this study. Future homeless mortality studies should account more fully for the length of time each individual has been homeless, as well as time spent sleeping outside, to better determine the contribution of chronicity to risk of mortality.

The potential for selection bias is another limitation of our study. People may have been living on the streets during enrollment who were not encountered or did not seek to access the BHCHP Street Team. Such individuals may differ from those enrolled and could potentially be healthier or younger and not interested in accessing health care providers. This was minimized by the Street Team having strong network of ties with all outreach workers and services in the Greater Boston area. Similarly the 123 people not included in the analysis due to insufficient identifiers to be linked to the MDPH death occurrence files may be systematically different from those included. The lack of identifying information may be because these individuals were homeless for briefer periods of time, more transient, or reluctant to give information because of severe mental illness. It was also possible that when the identifier became known it was added as a new record, thereby creating a duplicate record in the database. When encountering a person living outside, the BHCHP Street Team takes time to build a rapport with each individual. As a result most people, even with severe mental illness, became well known to the team. In maintaining the database used for this study, all attempts were made to confirm the identifiers for the

individuals included in the analysis by comparing the Access database records to that in the BHCHP EMR to conform name spelling, date of birth, and social security.

The primary source for information on deaths for the cohort came from the MDPH death occurrence files; persons who died in another state were less likely to be included in the analysis for this study. Individuals who traveled and subsequently died outside Massachusetts could be a source of selection bias insofar as those individuals capable of travel may differ from those unable or unwilling to do so. This limitation could be addressed in the future by applying for NDI data on the individuals considered alive at the end of the study, and such knowledge would mitigate concerns of attrition in our cohort study design.

Our study used criteria derived from previous mortality studies and clinical evidence that were hypothesized to predict mortality among homeless people living outside in an urban setting. These HR criteria and other criteria were used to create the VI, a self-reporting survey that was scored and used to prioritize vulnerable individuals when demand for housing exceeded availability. The HR criteria, in one sense, have been applied to unsheltered persons across the U.S. albeit not with the original intent. In terms of generalizability, there are likely to be people sleeping outside across the U.S. who are at a higher rate of mortality than others and the HR criteria developed by BHCHP could help in identifying them by paying closer attention to certain criteria when caring for individuals sleeping rough.

Future research

Future research should include variables such as length of time an individual has been homeless and living on the streets at the time of enrollment and throughout the study period, as well as access to supportive housing during the course of the study. Each of these can potentially influence mortality. In addition, future investigation might utilize a Cox model with each of the HR criteria instead of using a dichotomous variable to further understand which components of the HR criteria contributed to the increased mortality for those who are characterized as HR.

CONCLUSION

Using the HR criteria developed by BHCHP, for the HR group, we found a two times increased rate of death when compared to the NHR group, a four times greater rate of death when compared to a general homeless cohort, and a 15 times greater rate of death when compared to the population of MA. The unsheltered in the NHR group also had marked disparities in mortality, dying at more than twice the rate of the general homeless cohort and almost eight times that of the population of MA. Such marked disparities, are a clarion call for improved health, housing, and social services for this vulnerable group.

The use of HR criteria and other measures to prioritize the unsheltered population and other subgroups within the homeless population is a complex issue. Our results confirm that the unsheltered homeless population has a high-risk of mortality and we argue that supportive housing is imperative for all homeless people living outside if our society is to address health and social disparities outcomes for the unsheltered population in the U.S.

TABLES and FIGURES

Table 3-1: Characteristics of Unsheltered Cohort from 2000-2009

	Cohort N = 445	High-Risk ^a N = 119	Non-High-Risk N = 326	Decedents N = 134	Boston 2000 Census ≥18 years old N = 472,582 ^b	MA ^c 2000 Census ≥18 years old N = 4,849,033 ^d
Characteristic	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Age (years)						
18-44	248 (55.7)	57 (47.9)	191 (58.6)	56 (41.8)	306,658 (64.9)	2,569,111 (53.0)
45-64	176 (39.6)	57 (47.9)	119 (36.5)	65 (48.5)	104,588 (22.1)	1,419,760 (29.3)
≥65	21 (4.7)	5 (4.2)	16 (4.9)	13 (9.7)	61,336 (13.0)	860,162 (17.7)
Race/Ethnicity						
White	299 (67.2)	91 (76.5)	208 (63.8)	108 (80.6)	283,109 (59.9)	4,180,644 (86.1)
Black	94 (21.1)	16 (13.4)	78 (23.9)	15 (11.2)	102,491 (21.7)	236,027 (4.9)
^e Other/Unknown	52 (11.7)	12 (10.1)	40 (12.3)	11 (8.2)	86,982 (18.4)	432,362 (8.9)
Gender^f						
Men	322 (72.4)	91 (76.5)	231 (70.9)	116 (86.6)	224,078 (47.4)	2,289,671 (47.2)
Women	123 (27.6)	28 (23.5)	95 (29.1)	18 (13.4)	248,504 (52.6)	2,559,362 (52.8)
Risk-Level						
High-Risk	119 (26.7)			52 (38.8)		
Non-High-Risk	326 (73.3)			82 (61.2)		

^a Individuals were considered High-Risk if they slept on the street ≥6 months and met ≥1 of following 7 criteria: tri-morbidity (multiple medical illnesses co-occurring with mental illness and use of substances); ≥1 hospital admission or BHCHP respite admission during previous year due to major medical problem(s); ≥3 ED visits during previous 3 months; ≥60 years old; HIV or AIDS; cirrhosis, end stage liver disease, or renal failure; and/or previous history of frostbite, hypothermia, or immersion foot

^b Number reflects data on individuals ≥18 years old from Boston for the year 2000 from US Census Bureau: <http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml>

^c MA refers to Massachusetts

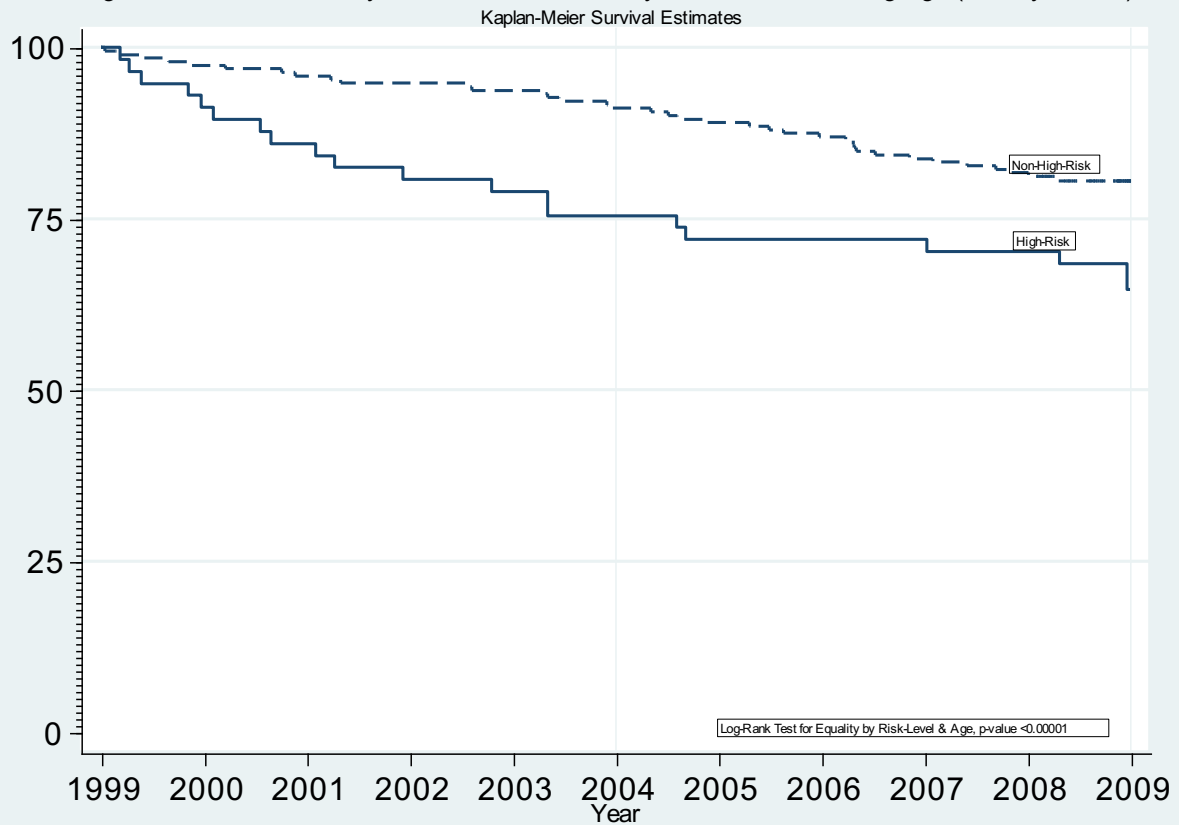
^d Number reflects data on individuals ≥18 years old from Massachusetts for the year 2000 from US Census Bureau:

<http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml>

^e Other Race/Ethnicity category contains individuals who reported their race/ethnicity to be American Indian, Hispanic, Asian, or race/ethnicity was unknown

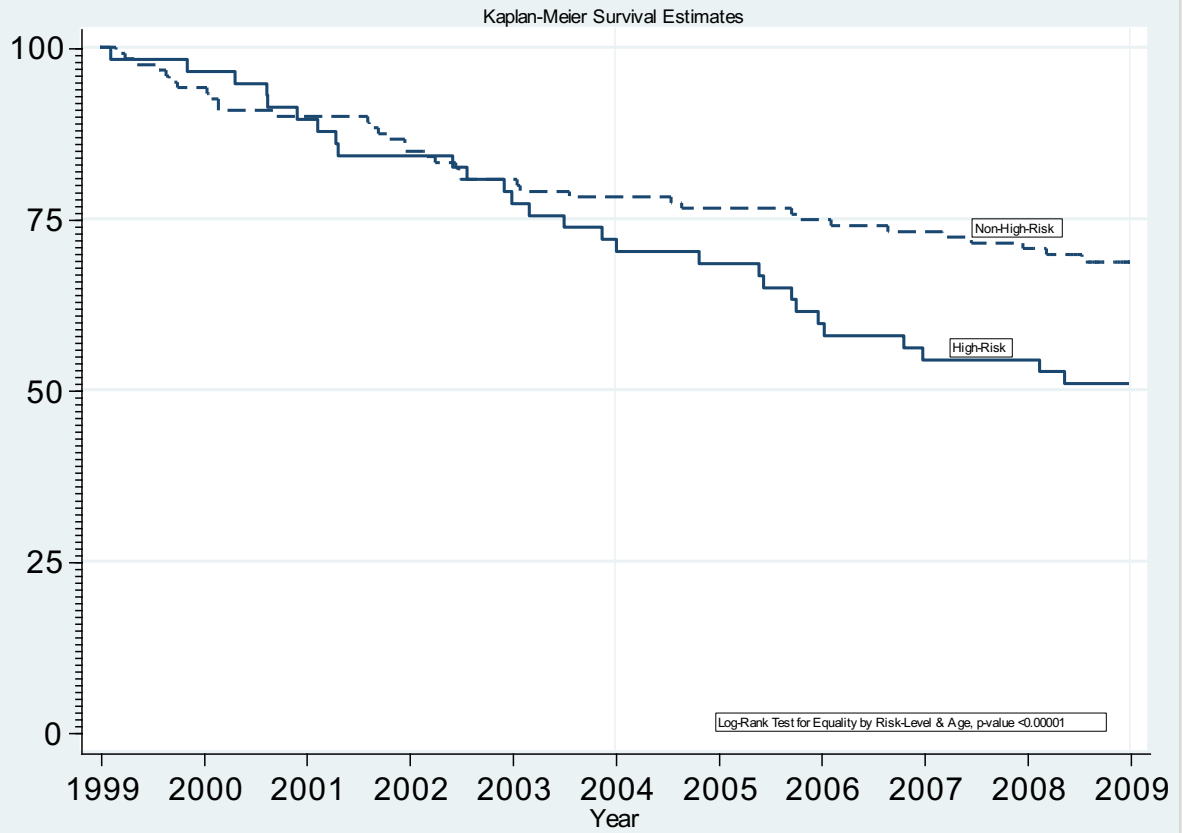
^f No missing data for Gender

Fig.3-1: All-Cause Mortality for Unsheltered Cohort by Risk-Level* and Young Age (18-44 years old)



*Individuals were considered High-Risk if they slept on the street ≥6 months and met ≥1 of following 7 criteria:
 tri-morbidity; ≥1 hospital or BHCHP respite admission during in 1 year; ≥3 ED visits during previous 3 months; ≥60 years old; HIV or AIDS; cirrhosis, end stage liver disease, or renal failure;
 and/or history of frostbite, hypothermia, or immersion foot

Fig.3-2: All-Cause Mortality for Unsheltered Cohort by Risk-Level and Middle Age (45-64 years old)



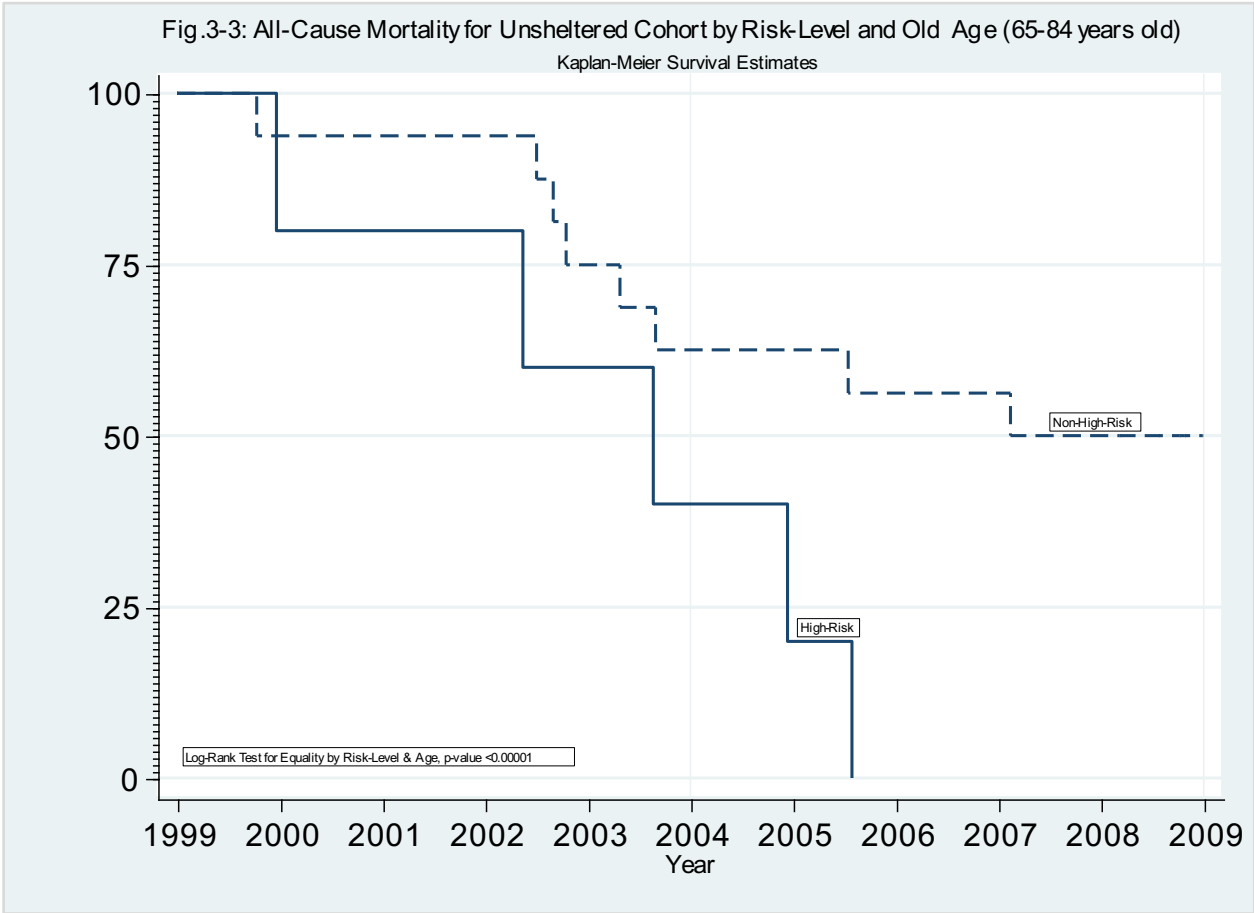


Table 3-2: Cox Proportional Hazard Model for the Unsheltered Cohort from 2000-2009

Model One (Age, Gender, Race/Ethnicity, High-Risk ^a)			
	Hazard Ratio (95% CI ^b)	p-value (0.05)	Global Test p-value (0.05)
Age (years)			0.0005
18-44	1.0		
45-64	1.5 (1.0, 2.1)	0.032	
65-84	3.6 (2.0, 6.7)	<0.0001	
Race/Ethnicity			0.0031
White	1.0		
Black	0.5 (0.3, 0.8)	0.006	
^c Other/Unknown	0.5 (0.3, 1.0)	0.054	
Gender ^d			
Women	1.0		
Men	2.7 (1.6, 4.4)	<0.0001	
Risk-Level			
Non-High-Risk	1.0		
High-Risk	1.7 (1.2, 2.4)	0.003	

^a Individuals were considered High-Risk if they slept outside on the street ≥ 6 months and met ≥ 1 of following 7 criteria: tri-morbidity (multiple medical illnesses co-occurring with mental illness and use of substances); ≥ 1 hospital admission or BHCHP respite admission during previous year due to major medical problem(s); ≥ 3 ED visits during previous 3 months; ≥ 60 years old; HIV or AIDS; cirrhosis, end stage liver disease, or renal failure; and/or previous history of frostbite, hypothermia, or immersion foot

^b CI refers to Confidence Interval

^c Other Race/Ethnicity category contains individuals who reported their race/ethnicity to be American Indian, Hispanic, Asian, or race/ethnicity was unknown

^d No missing data for Gender

Table 3-3: Age Specific, Race/Ethnicity Specific, Gender Specific, and Risk-Level Specific Mortality Rate Ratios for Unsheltered Cohort from 2000-2009

		Deaths	Person-years	Mortality Rate Deaths/100,000 Person-years (95% CI) ^a	Rate Ratio (95% CI)	p-value (0.05)
Overall		134	3608.7	3713.2 (3110.9, 4397.5)		
Age (years)						
	18-44	56	2124.6	2635.8 (1990.7, 3422.2)	1.0	
	45-64	65	1350.3	4813.8 (3716.0, 6136.9)	1.6 (1.1, 2.2)	0.0091
	65-84	13	133.8	9715.9 (5165.694, 16589.9)	2.8 (1.4, 5.0)	0.0020
Race/Ethnicity						
	White	108	2325.2	4644.7 (3810.5, 5608.3)	1.0	
	Black	15	835.4	1795.5 (1005.4, 2962.9)	0.4 (0.2, 0.7)	0.0001
	^b Other/Unknown	11	448.1	2455.1 (1225.7, 4393.3)	0.5 (0.3, 1.0)	0.0321
Gender ^c						
	Women	18	1130.6	1592.1 (943.2, 2515.3)	1.0	
	Men	116	2478.1	4681.0 (3868.2, 5614.7)	2.9 (1.8, 5.1)	<0.0001
Risk-Level ^d						
	Non-High-Risk	82	2730.8	3002.6 (2388.0, 3727.0)	1.0	
	High-Risk	52	877.9	5922.6 (4423.2, 7766.6)	2.0 (1.4, 2.8)	0.001

^a CI refers to Confidence Interval

^b Other Race/Ethnicity category contains individuals who reported their race/ethnicity to be American Indian, Hispanic, Asian, or race/ethnicity was unknown

^c No missing data for Gender

^d Individuals were considered High-Risk if they slept on the street ≥6 months and met ≥1 of following 7 criteria: tri-morbidity (multiple medical illnesses co-occurring with mental illness and use of substances); ≥1 hospital admission or BHCHP respite admission during previous year due to major medical problem(s); ≥3 ED visits during previous 3 months; ≥60 years old; HIV or AIDS; cirrhosis, end stage liver disease, or renal failure; and/or previous history of frostbite, hypothermia, or immersion foot

Table 3-4: Age Specific Rate Ratios for Unsheltered High-Risk Cohort, 2000-2009 Compared to Massachusetts Population, 2000-2009 and to General Homeless Cohort from Boston, MA, 2003-2008^a

Age (years)	High-Risk Deaths	Mortality Rate/100,000 PY ^b (95% CI) ^c	MA ^d Deaths	Mortality Rate/100,000 Pop. (95% CI)	RR ^e (95% CI) High-Risk vs. MA	General Homeless Deaths	Mortality Rate/100,000 PY (95% CI)	RR (95% CI) High-Risk vs. General Homeless
18-44	19	4308.4 (2593.9, 6728.1)	26198	105.6 (104.3, 106.9)	40.8 (24.6, 63.7)	365	738.6 (664.7, 818.4)	5.8 (3.5, 9.2)
45-64	28	6747.0 (4483.3, 9751.3)	84036	521.3 (517.8, 524.8)	12.9 (8.6, 16.3)	796	2137.6 (1991.7, 2291.4)	3.2 (2.1, 4.6)
65-84	5	22727.3 (7379.5, 53037.9)	243241	3319.5 (3306.4 - 3332.7)	7.0 (2.3, 16.3)	136	3668.5 (3078.1, 4339.7)	6.3 (2.0, 15.2)
All Ages	52	5922.6 (4423.2, 7766.6)	353475	732.4 (730.0, 734.8)		1297	1435.3 (1358.3, 1515.6)	

^a General Homeless Cohort from Boston, MA, 2003-2008 used for comparison from Baggett, TP et al. *Mortality Among Homeless Adults in Boston: Shifts in Causes of Death Over a 15-Year Period*. JAMA 2013 Feb; 173 (3): 189-195

^b PY refers to Person-years

^c CI refers to Confidence Interval

^d MA refers to Massachusetts

^e RR refers to Rate Ratio

Table 3-5: All-Cause Mortality and Cause-Specific Age-Standardized Mortality Ratios for the Unsheltered Cohort, 2000-2009 by Risk-Level Compared to the Massachusetts Population, 2000-2009 and to a General Homeless Cohort from Boston, MA, 2003-2008^a

Underlying Cause of Death ^{c,*}	High-Risk ^b			Non-High-Risk		
	N=52 (%)	SMR ^d (95% CI) ^e HR ^f vs. MA ^g	SMR (95% CI) HR vs. General Homeless	N=82 (%)	SMR (95% CI) NHR ^h vs. MA	SMR (95% CI) NHR vs. General Homeless
All-Cause						
Risk-Level	52 (100)	15.5 (11.7, 20.2)	4.0 (3.0, 5.2)	82 (100)	7.9 (6.3, 9.8)	2.2 (1.8, 2.8)
Men	45 (86.5)	15.0 (11.1, 19.9)	4.2 (3.1, 5.6)	71 (86.6)	7.4 (5.8, 9.2)	2.4 (1.9, 3.0)
Women	7 (13.5)	9.5 (4.2, 18.8)	3.0 (1.2, 5.7)	11 (13.4)	5.4 (2.9, 9.5)	1.6 (0.9, 2.8) [†]
Natural Causes						
Chronic Liver Disease	11 (21.2)	86.0 (45.0, 150.0)	11.7 (6.2, 20.4)	*		
Cancer	9 (17.3)	8.1 (4.0, 15.0)	4.5 (2.2, 8.2)	12 (14.6)	3.7 (2.0, 6.3)	2.2 (1.2, 3.7)
Heart Disease	7 (13.5)	10.4 (4.5, 20.5)	3.5 (1.5, 7.0)	11 (13.4)	5.2 (2.7, 9.0)	2.0 (1.0, 3.4) [†]
Substance Use Disorder	5 (9.6)	104.2 (38.1, 231.0)	4.9 (1.8, 10.9)	11 (13.4)	83.5 (43.8, 144.8)	4.0 (2.0, 6.8)
HIV/AIDS	5 (9.6)	122.3 (44.8, 271.1)	6.5 (2.4, 14.4)	5 (6.1)	43.1 (15.8, 95.5)	2.3 (0.8, 5.1) [†]
External Causes						
Injuries, non-poisoning ⁱ	6 (11.5)	44.0 (17.8, 91.6)	8.4 (3.4, 17.5)	13 (15.9)	30.0 (16.7, 50.0)	6.7 (3.7, 11.1)
Drug Overdose (poisoning)	*			7 (8.5)	16.2 (7.1, 32.1)	1.1 (0.5, 2.1) [†]
Substance Use Causes						
Substance Use	17 (32.7)	75.2 (45.2, 117.9)	4.1 (2.5, 6.5)	22 (26.8)	32.9 (21.1, 48.9)	1.9 (1.2, 2.8)
Alcohol	16 (30.8)	212.5 (125.8, 337.7)		14 (17.1)	71.1 (40.5, 116.4)	
Opioid	*			8 (9.8)	18.4 (8.5, 34.9)	

^a General Homeless Cohort from Boston, MA, 2003-2008 used for comparison from Baggett, TP et al. *Mortality Among Homeless Adults in Boston: Shifts in Causes of Death Over a 15-Year Period*. JAMA 2013 Feb; 173 (3): 189-195

^b Individuals were considered High-Risk if they slept on the street ≥6 months and met ≥1 of following 7 criteria: tri-morbidity (multiple medical illnesses co-occurring with mental illness and use of substances); ≥1 hospital admission or BHCHP respite admission during previous year due to major medical problem(s); ≥3 ED visits during previous 3 months; ≥60 years old; HIV or AIDS; cirrhosis, end stage liver disease, or renal failure; and/or previous history of frostbite, hypothermia, or immersion foot

^c No unknown Causes of Death

^d SMR refers to Standardized Mortality Ratio and were calculated for deaths ≥5

^e CI refers to Confidence Interval

^f HR refers to High-Risk

^g MA refers to Massachusetts

^h NHR refers to Non-High-Risk

ⁱ Injuries, non-poisoning category contains Transportation Accidents codes V01-V99, Other External Causes of Accidental Injuries codes W00-X59 except for X40-X49 which represent accidental poisonings by noxious substances, and Events of Undetermined Intent codes Y20-Y34 except for codes Y10-Y19 which represent poisonings of undetermined intent. Methodology in collapsing ICD-10 categories based on similar methodology in Health of Boston 2014-2015 Report from the Boston Public Health Commission: http://www.bphc.org/healthdata/health-of-boston-report/Documents/HOB-2014-2015/FullReport_HOB_2014-2015.pdf

* Causes of death <5 were suppressed; these were: diseases of digestive system, Influenza and Pneumonia, Chronic Lower Respiratory Disease, Infection (Sepsis, Viral Hepatitis), Anoxic Brain Injury, Cerebrovascular Disease, Renal Failure, Central Nervous System Disease, Mental Disorder, Ill-Defined Conditions, Suicide, Homicide

[†] SMR not significant at p-value <0.05 level; all SMRs without symbol were significant at p-value <0.05

Supplemental Table: International Classification of Diseases 10th Revision (ICD-10) Codes Used and Definitions of Causes of Death			
Underlying Cause of Death ^a	ICD-10 Codes Range	ICD-10 Codes from Unsheltered Cohort	Definitions
Natural Causes			
Infection (Sepsis, Viral Hepatitis)	A30-A49, B90-B94	A41, B94	Acute infectious disease
HIV/AIDS disease	B20-B24	B20, B22, B23, B24	Symptomatic HIV/AIDS disease, not asymptomatic disease
Cancer	C00-C97	C15, C18, C20, C26, C32, C34, C41, C55, C61, C79, C85	Malignant neoplasms only, not benign tumors
Mental Disorders	F01-F09	F09	Primary and secondary symptomatic mental disorders
Substance Use Disorder	F10-F19	F10-F11	Death from the use of one or more substances such as alcohol or opioids
Central Nervous System Disease	G10-G14	G10	Central nervous system disease from atrophies
Anoxic Brain Injury	G90-G98	G93	Nervous system disorders including brain injuries
Heart Disease	I00-I51	I11, I21, I24-I25, I27, I42, I46, I50	All diseases involving the heart, not cerebrovascular related
Cerebrovascular Disease	I60-I69	I61, I64	All cerebrovascular related diseases, excluded heart disease
Influenza and Pneumonia	J09-J18	J15, J18	Influenza from influenza virus and/or all acquired pneumonias
Chronic Lower Respiratory Disease	J40-J47	J44	Chronic Lower Respiratory Disease including bronchitis and Chronic Obstructive Pulmonary Disease
Diseases of Digestive System	K00-K66, K80-K92	K55, K62, K92	Digestive system disease including vascular disorders, prolapse, and unspecified
Chronic Liver Disease	K70-K76	K70, K72, K74, K76	Alcoholic and toxic liver disease, hepatic failure, chronic hepatitis, fibrosis and cirrhosis, excluded viral hepatitis
Renal Failure	N17-N19	N18-N19	Renal failure due to congenital or exogenous causes
Ill-Defined Conditions	R00-R99	R62, R99	Clinical findings and diseases not classified elsewhere
External Causes			
Injuries, non-poisoning	V01-V99, W00-X39, X50-X59, Y20-Y34	W05, W10, W19, W74, W80, X31, X59, V03, V05, V09, V29, Y21, Y31, Y34	Death from injuries other than from poisonings
Drug Overdose (poisoning)	X40-X49, Y10-Y19	X42, X44, Y12, Y14	Death from overdose attributable to poisonings by one or more substances of abuse such as alcohol or opioids
Suicide	X60-X84	X71	Death from Intentional self-harm
Homicide	X85-Y09	X99, Y09	Death from assault
Additional Groupings			
Substance Use	F10-F19, K70, X40-X49, Y10-Y19	F10-F11, K70, X42, X44, Y12, Y14	Deaths from the use of one or more substances of abuse, including overdose from poisonings
Alcohol	F10, K70, X45, Y15	F10, K70-K76	Deaths attributable to the use of alcohol, including poisoning from alcohol
Opioids	F11, F19, X42-X44, Y12-Y14	F11, X42, X44, Y12, Y14	Deaths attributable to the use of opioids, including overdose poisoning from opioids

^a No unknown Causes of Death

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